P4 PRODUCTION
SOUTHEAST IDAHO MINE-SPECIFIC
SELENIUM PROGRAM

Phase I Site Investigations
for Enoch Valley, Henry, and Ballard Mines
Draft Interim Phase I SIs Evaluation Summary – Version 2

Prepared by

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November 2007

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ACRONYMS AND ABBREVIATIONS

AOC	administrative order on consent
BM	Ballard Mine
BMP	best management practices
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
COPC	constituent of potential concern
DQO	data quality objective
dw	dry weight
EE/CA	engineering evaluation/cost analysis

ACRONYMS AND ABBREVIATIONS (continued)

EVM	Enoch Valley Mine
GW	groundwater
HM	Henry Mine
IDEQ	Idaho Department of Environmental Quality
IDWR	Idaho Department of Water Resources
i.e.	id est (Latin, that is to say; in other words)
IMA	Idaho Mining Association
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MTL	maximum tolerance levels
MOU	Interagency Memorandum of Understanding concerning Contamination from Phosphate Mining Operations in Southeast Idaho
MWH	MWH, Inc. (formerly Montgomery Watson, Inc.)
NA	not analyzed
NE	not electrofished
NR	not reported
NRC	National Research Council of the National Academies
NS	not sampled
NWI	National Wetlands Inventory
ORNL	Oak Ridge National Laboratory
P4	P4 Production, L.L.C.
PCA	principal components analysis
PEC	probable effects concentration
PgmHSP	program health and safety plan
PgmFSP	program field sampling plan
PgmQAP	program quality assurance plan
Phase I SIs	phase I site investigations
PjtFSP	project field sampling plan
PjtWP	project work plan
PRBB	preliminary risk-based benchmark
RBS	rapid bioassessment score
SAP	sampling and analysis plan
SE	sediment
SI	site investigation
SI-ES	Interim Phase I SIs Evaluation Summary
SO	soil
Solutia	Solutia, Inc.
SOP	standard operating procedure
SW	surface water
SWD	spatial wire diagram
TtEMI	TetraTech EM, Inc.
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency

ACRONYMS AND ABBREVIATIONS (continued)

USFS	United States Forest Service
USGS	United States Geological Survey
VE	vegetation

1.0 INTRODUCTION

This *Interim Phase I SIs Evaluation Summary* (SI-ES) is submitted by P4 Production, L.L.C. (P4) to document the evaluation of the Phase I Site Investigations (Phase I SIs) conducted at P4's Enoch Valley, Henry, and Ballard mines. The evaluation is conducted programmatically, combining all three mine's site investigations (SIs). This SI-ES incorporates all of the results from the Phase I-SI data collection activities conducted in 2004 (except groundwater), and relative historic background data (1997-2003). The results of the groundwater data collection activities conducted in 2004, additional Phase II groundwater activities conducted during 2005, and relative historic data (1997-2003) are evaluated and reported in the Phase II Monitoring Well Installation Technical Memorandum (MWITM), draft version 4 (MWH, 2006).

The 2004 data collection activities were conducted in accordance with the requirements of the administrative order on consent (AOC) signed by P4, Idaho Department of Environmental Quality (IDEQ), United States Environmental Protection Agency (USEPA), and the United States Forest Service (USFS) and formally executed on November 14, 2003 (IDEQ, 2003b). Specifically, the data collection activities were conducted in accordance with each mine's project work plan (PjtWP)—(MWH, 2004a), project field sampling plan (PjtFSP)—(MWH, 2004c), program sampling and analysis plan (SAP)—(MWH, 2004d), and subsequent approved sampling plans/technical memorandums, including the following:

- *P4 Production SI Seasonal Vegetation Investigation* (technical memorandum)—(included in Appendix H);
- *P4 Production SI Benthic Macroinvertebrate Investigation* (technical memorandum) —(included in Appendix I);
- *Field Investigation Update July 2004 Mass Wasting Sampling Effort* (technical memorandum)—(included in Appendix J);
- *Chromium Speciation Sampling Memo* (B. Wright, MWH [Memorandum to R. Clegg, IDEQ] June 1, 2005); and
- *Final Phase II Supplemental SI Groundwater Work Plan* (MWH, 2005b).

The Interim Surface Water and Sediment Investigation was conducted in accordance with the draft AOC and according to IDEQ approved interim work plans and sampling and analysis plans. All other historic data was conducted according to IDEQ approved sampling plans and/or USEPA investigation protocols.

The work scope included the collection and analyses of surface water, sediment, benthic macroinvertebrate, groundwater, soil, vegetation, and fish tissue samples from in and around the P4 Enoch Valley, Henry, and Ballard mines.

The SI-ES is organized into the following sections:

- Section 1 – Introduction: This section presents an introduction to and the organization of the SI-ES.
- Section 2 – Program Background: This section provides the program history.
- Section 3 – Investigation Objectives: This section presents the program objectives of the SIs and briefly describes how the objectives will be achieved.
- Section 4 – Background Calculations: This section summarizes the PI-SI background calculations.
- Section 5 – Data Evaluation and Discussion: This section presents the results, an evaluation of the results, and a discussion of the results by medium and/or specific task, subtask, or activity (i.e., chromium speciation).
- Section 6 – References: This section lists references cited.

2.0 PROGRAM BACKGROUND

This section provides the program history relating to all three P4 mines: Enoch Valley, Henry, and Ballard Mines.

2.1 PROGRAM HISTORY

Phosphate mining has been an ongoing activity within the Southeast Idaho Resource Area since Conda Mine started operations in 1919. Today four companies including P4 operate phosphate mines in the Resource Area, and the ore obtained from these mines is locally processed into fertilizer and elemental phosphorous, two important products in the world's economy. Phosphate mining and processing form an important economic foundation for southeast Idaho.

In late 1996, six horses pastured downstream of a closed, reclaimed phosphate mine were diagnosed with chronic selenosis. This event prompted concern by mine operators, the public, local, state and federal agencies about potential selenium impacts to the environment. To address these concerns, the Idaho Mining Association (IMA) formed a Selenium Committee in early spring 1997 to identify the source and extent of selenium and other trace element impacts associated with phosphate mining activities. The IMA voluntarily conducted multiple regional investigations through June 2000 and developed mitigation measures to address selenium and other target element releases and to minimize the potential threat to the environment. The IMA assisted IDEQ with data collection as part of the 2001 Area-Wide Study discussed below.

In July 2000, federal, tribal, and state agencies signed an *Interagency Memorandum of Understanding concerning Contamination from Phosphate Mining Operations in Southeast Idaho* (MOU) (IDEQ, 2000). The MOU specified the IDEQ as the lead agency for coordinating the Area Wide Investigation and for establishing regional clean-up guidance to assist lead agencies in implementing future site-specific remedial efforts in the Southeast Idaho Phosphate Mining Resource Area.

The IDEQ contracted TetraTech EM, Inc. (TtEMI) to assist in the 2001 Area-Wide Study and in the development of human health and ecological risk assessments associated with past phosphate mining operations in the Resource Area. The risk assessment work was conducted as part of the Area-Wide Scope of Work referenced in the MOU. IDEQ published the *Final Area Wide Human Health and Ecological Risk Assessment, Selenium Project Southeast Idaho Phosphate Mining Resource Area* in December 2002 (IDEQ 2002). The risk assessment was performed on an area-wide basis and concluded that regional human health risks and population-level ecological risks are unlikely based on current conditions, and that the areas impacted by historic and on-going releases are limited to approximately 5% of the overall Resource Area. The human health assessment did identify several areas that could present elevated risks under conditions of sole use over extended periods of time such as residential use of waste rock piles or fish diets exclusively limited to a few impacted first order streams. However, these conditions were considered highly unlikely based on area land use and regional observations over the past five years.

It is thought that these risks remain low because it is assumed that contaminant transport has reached steady-state. To demonstrate these steady state conditions we performed a regression analysis of selenium concentration over time for three stations, one for each of the three mines. The analysis is shown as figure 2-5. The stations were chosen explicitly as “worst case scenarios” because of their close proximity to their respective mine, and their historically relatively high selenium concentrations. While none of these regressions are significant, the data support our null hypothesis that we believe the transport mechanisms have reached steady state and that contamination is not worsening. With each respective R-value being below the critical R-value of 0.90, the regression’s support the null hypothesis for Ballard and Henry mines, and do not reject this hypothesis for Enoch Valley. Furthermore, Monsanto has agreed to additional surface water sampling in May 2008 and 2009 that will extend these plots further and lead to better characterization. Please note that while this was not a large task in and of itself, characterizing and observing change over time is not the primary goal of a site investigation. A site investigation should be focused upon assessing and characterizing risk.

In April 2003, IDEQ published the *Final Draft Area Wide Risk Management Plan* (IDEQ, 2003a). The purpose of the plan is to provide regional risk management guidance for addressing releases of selenium and related trace metals originating from historic phosphate mining operations in Southeast Idaho. The proposed action levels, remedial action goals and remedial action objectives are intended to assist the designated lead agencies and mining companies in selecting individual site remedies that focus the use of limited resources and support a consistent regional approach to risk management. The document provides a brief summary of Area Wide activities to date, a synopsis of the removal action process being implemented to address mine-specific concerns, and a comprehensive discussion of risk management issues, including goals and objectives, and the development of risk-based action levels.

MWH and P4 have an extensive understanding of the area as a result of all the previous Selenium Investigations that have been ongoing since 1997. A comprehensive data set exists of historical data from various media. P4, under the umbrella of the IMA, participated in extensive sampling throughout the Southeast Idaho Phosphate Resource Area. P4 has information regarding Enoch Valley, Henry, and Ballard mines from 1997-present, with various media being sampled at, and adjacent to, the mines. These have included the following media:

- Benthic macroinvertebrates;
- Forage fish;
- Salmonids;
- Small mammals;
- Terrestrial invertebrates;
- Terrestrial worms;
- Plankton;
- Periphyton;
- Groundwater;
- Riparian vegetation;
- Submergent macrophytes;
- Surface soils;
- Sediment;

- Surface water;
- Vegetation;
- Beef;
- Bird eggs; and,
- Elk.

P4 initiated a fourteen-month Interim Surface Water and Sediment Investigation in May 2002 for Enoch Valley, Henry and Ballard mines, the results of which will be reported in the comprehensive SI Report (MWH 2002a, MWH 2002b).

For a map of the three mines and their associated facilities and drainages, see Figure 2-1, *Program Sampling Locations,* which covers the entire program area. For expanded maps for each mine site see Figure 2-2 (Enoch Valley Mine Detail), Figure 2-3 (Henry Mine Detail), and Figure 2-4 (Ballard Mine Detail). For additional site-specific maps and site-specific backgrounds of these mines, see the appropriate mine-specific PjtFSPs.

In August 2003, MWH prepared a *Summary of Work Performed to Date Under Various Southeast Idaho Selenium Programs* (MWH, 2003) for P4 that summarized the conclusions of all selenium related investigations, studies, and reports completed by the IMA Selenium Committee, private companies, government agencies, and representatives thereof. The summary consists of reports produced since 1997 under one of the various industry- or agency-conducted selenium-response programs in the Resource Area. Such reports that are in any way pertinent to P4's Southeast Idaho Mine-Specific Selenium Program are presented in the summary by production date.

An AOC was signed by P4, IDEQ, USEPA, and USFS and formally executed on November 14, 2003. In accordance with the requirements of the administrative order on consent, MWH prepared the final Comprehensive SI and Engineering Evaluation/Cost Analyses (EE/CA) work plans (MWH, 2004a & 2004b, respectively) for Enoch Valley, Henry, and Ballard mines in January 2004 and prepared the SAP in April 2004.

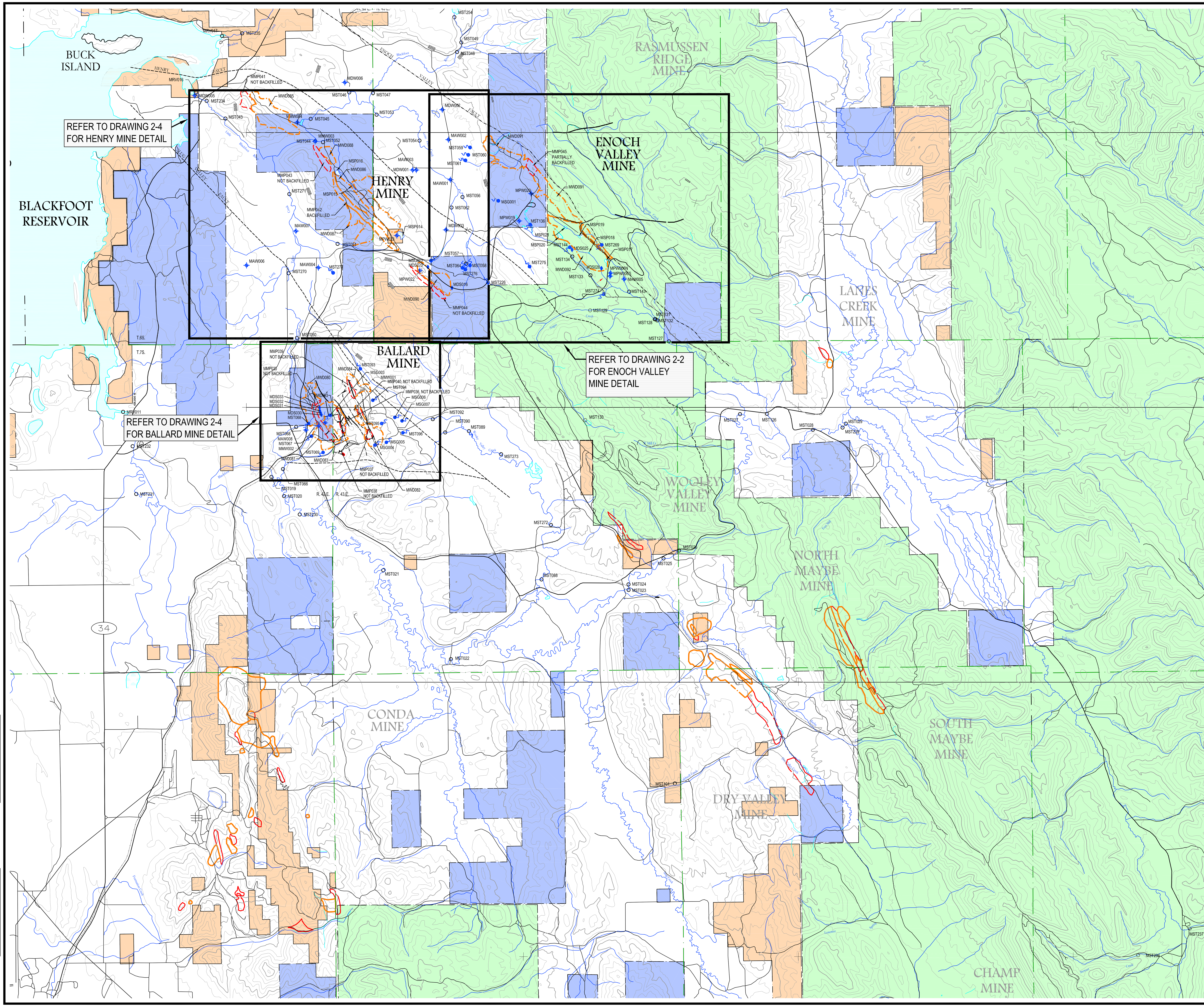
For additional details on the regional history and for descriptions of the previous IMA Selenium Investigations can be found in Section 2.4 of the EE/CA work plans (MWH, 2004b) for Enoch Valley, Henry, and Ballard mines, which is identical for each mine.

2.2 P4 VOLUNTARY ACTIONS

To date, P4 has undertaken a variety of voluntary actions in and around the mine sites to abate the release of selenium from waste rock. These actions include:

- Road construction using low-selenium content materials;
- Ditch liners to prevent runoff infiltration;
- Directing run-on water around disturbed areas;
- Directing overburden or backfill runoff;
- Material placement to prevent contamination from mined materials;
- Encapsulated overburden dumps;
- Non-shale overburden dumps;
- Caps and covers of waste rock piles;
- Partially backfilling final mine pits to cover exposed ore bodies;
- Position of final pit at highest elevation to reduce the formation of pit lakes;
- Topsoil management; and,
- Noxious and selenium-accumulating weed control program.

More information regarding these programs will be available from the agency/industry draft of *Best Management Practice Guidance Manual for Active and Future Phosphate Mines* (MWH, 2000).



LEGEND

- CONTOURS (IN METERS)
- CREEKS/RIVERS
- PONDS
- MARSH
- HIGHWAY
- ROADS
- RAILROAD
- STATE LINE
- COUNTY LINE
- TOWNSHIP AND RANGE
- MINE PIT LOCATION (APPROXIMATE)
- WASTE ROCK PILE LOCATION (APPROXIMATE)
- FAULT
- INFERRED FAULT
- FAULT CONCEALED BY SURFACE DEPOSITS
- MPW023 GROUNDWATER WELL MONITORING LOCATION
- MDS022 WASTE ROCK DUMP SEEP
- MSG002 SPRING STATION
- MST054 STREAM STATION
- NATIONAL FOREST
- BUREAU OF LAND MANAGEMENT
- STATE OF IDAHO
- PRIVATE LAND

NOTES:

MAW = AGRICULTURAL WELL
MDW = DOMESTIC WELL
MMW = MONITORING WELL
MPW = PRODUCTION WELL
MDS = DUMP SEEP
MST = SPRING FED STREAM LOCATION
MMP = MINE PIT
MWD = WASTE ROCK DUMP
MSP = POND
MSG = SPRING
MRV = RESERVOIR DELTA

STATE OF IDAHO
STUDY AREA
MAP KEY

SCALE
0 4000' 8000'
CONTOUR INTERVAL: 40 Meters
USGS 1:100,000 SODA SPRINGS
TOPOGRAPHIC BASE (1982)

REV. No.	REVISIONS	DATE	DESIGN BY	DRAWN BY	REVIEWED AND SIGNED BY
3	Issued for V2	03/07	D.Brame	S.Farnam	
2	Issued for Review	4/13/05	P.Stenhouse	C.Taylor	M.Rettmann
1	Issued for Review	3/31/05	P.Stenhouse	C.Taylor	P.Stenhouse

P4 PRODUCTION
Southeast Idaho Mine - Specific Selenium Program

PROJECT:
Interim Phase I SIs Evaluation Summary

DRAWING TITLE:
SOUTHEAST IDAHO MINE SPECIFIC SELENIUM PROGRAM AREA

MWH

Sheet 1 Of 1 Sheets
SCALE: As Shown
DRAWING No. 2-1

AutoCAD FILE: V5-Dwg 2-1 Site Location Map.dwg PROJECT NUMBER 1010076.011801


ENOCH VALLEY MINE
ENOCH VALLEY FAULT
HENRY FAULT
LEGEND
CONTOURS (IN METERS)
CREEKS/RIVERS
PONDS
HIGHWAY
ROADS
RAILROAD
TOWNSHIP AND RANGE
FAULT LINE
INFERRED FAULT
FAULT CONCEALED BY SURFACE DEPOSITS
MINE PIT LOCATION (APPROXIMATE)
WASTE ROCK PILE LOCATION (APPROXIMATE)
MPW023 GROUNDWATER WELL MONITORING LOCATION
MDS022 WASTE ROCK DUMP SEEP
MSG002 SPRING STATION
MST134 STREAM STATION
NATIONAL FOREST
BUREAU OF LAND MANAGEMENT
STATE OF IDAHO
PRIVATE LAND
NOTES:
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MWD = WASTE ROCK DUMP
MSP = POND
MSG = SPRING
MRV = RESERVOIR DELTA
STATE OF IDAHO
STUDY AREA
MAP KEY
SCALE
0 2000' 4000'
CONTOUR INTERVAL: 10 Feet
MDW002
MAW002
MST059
MST060
MST061
MAW001
MST056
MST062
MDW003
MWD091
MMP045 PARTIALLY BACKFILLED
MPW020
MSG001
MPW019
MST136
MSP019
MSP021
MSP020
MSP018
MST269
MSP017
MST144
MDS025
MST134
MDS026
MST275
MST057
MSG002
MST058
MST064
MST276
MWD090
MST226
MDS016
MMP044 NOT BACKFILLED
MWD092
MST133
MPW006
MAW005
MST143
MST274
MST129
MST128
MST131
MST132
MST127
W. Rasmussen Ridge Creek
Lone Pine Creek
Creek
Strip Mine Creek
W. Fork Lone Pine Creek
E. Fork Lone
Pine Creek
W. Fork No Name Creek
E. Fork No Name Creek
No Name Creek
Sheep Creek
Daves Creek
Rasmussen Creek
E. Fork Rasmussen Creek
W. Fork Rasmussen Creek
Angus Creek
0 | Issued for V2 | 0 | D.Brame | S.Farnam
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P4 PRODUCTION
Southeast Idaho Mine-Specific Selenium Program
PROJECT:
Interim Phase I SIs Evaluation Summary
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ENOCH VALLEY MINE DETAIL
MWH
Sheet 1 Of 1 Sheets
SCALE: As Shown
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PROJECT NUMBER 1010076.011801
AutoCAD FILE: V5-Dwg 2-2 Enoch.dwg


LEGEND
CONTOURS (IN METERS)
CREEKS/RIVERS
PONDS
HIGHWAY
ROADS
RAILROAD
TOWNSHIP AND RANGE
FAULT LINE
INFERRED FAULT
FAULT CONCEALED BY SURFACE DEPOSITS
MINE PIT LOCATION (APPROXIMATE)
WASTE ROCK PILE LOCATION (APPROXIMATE)
MPW023 GROUNDWATER WELL MONITORING LOCATION
MDS022 WASTE ROCK DUMP SEEP
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MWD = WASTE ROCK DUMP
MSP = POND
MSG = SPRING
MRV = RESERVOIR DELTA
HENRY MINE
MRV016
MDW005
MST234
MMP041
NOT BACKFILLED
MWD085
MST046
MST047
MST053
MST043
MMW004
MST045
Little Blackfoot River
MST052
MST044
MMW003
MWD088
MMP043
NOT BACKFILLED
MSP016
MWD086
Long Valley Creek
MSP015
MST271
MWD087
MMP042
BACKFILLED
MPW023
MSP014
MAW007
MST051
SLUG VALLEY FAULT
ENOCH VALLEY
HENRY FAULT
MDW002
Lone Pine Creek
MST054
MAW002
MST059
MST060
MST061
W. Rasmussen Ridge Creek
MAW003
MDW001
MMW005
MAW001
MST056
MST062
MDW003
Strip Mine Creek
E. Fork Lone Pine Creek
MST057
W. Fork Lone Pine Creek
MSG002
MPW022
MDS022
MWD090
MST058
MST064
MST276
MST226
MDS016
MMP044
NOT BACKFILLED
MAW006
MAW004
MST270
MST277
MST050
STATE OF IDAHO
STUDY AREA
MAP KEY
N
SCALE
0 2000' 4000'
CONTOUR INTERVAL: 10 Feet
0 | Issued for V2 | 03/07 | D.Brame | S.Farnam
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PROJECT:
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HENRY MINE DETAIL
MWH
Sheet 1 Of 1 Sheets
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BALLARD MINE
LEGEND
CONTOURS (IN METERS)
CREEKS/RIVERS
PONDS
HIGHWAY
ROADS
RAILROAD
TOWNSHIP AND RANGE
FAULT LINE
INFERRED FAULT
FAULT CONCEALED BY SURFACE DEPOSITS
MINE PIT LOCATION (APPROXIMATE)
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MMP = MINE PIT
MWD = WASTE ROCK DUMP
MSP = POND
MSG = SPRING
MRV = RESERVOIR DELTA
MMP039 NOT BACKFILLED
MST093
MWD084
MWD080
MMP035 NOT BACKFILLED
MMP040 NOT BACKFILLED
MWD093
SLUG VALLEY FAULT
MSG003
MST068
MAW008
MST067
MMP036 NOT BACKFILLED
MST095
MST092
MSG005
MSG004
MWD081
MMP037 NOT BACKFILLED
MST069
MWD082
MMP038 NOT BACKFILLED
MWD083
MST069
MST066
MST019
STATE OF IDAHO
STUDY AREA
MAP KEY
N
SCALE
0 600' 1200'
0 Issued for V2 03/07 D.Brame S.Farnam
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BALLARD MINE DETAIL
MWH
Sheet 1 Of 1 Sheets
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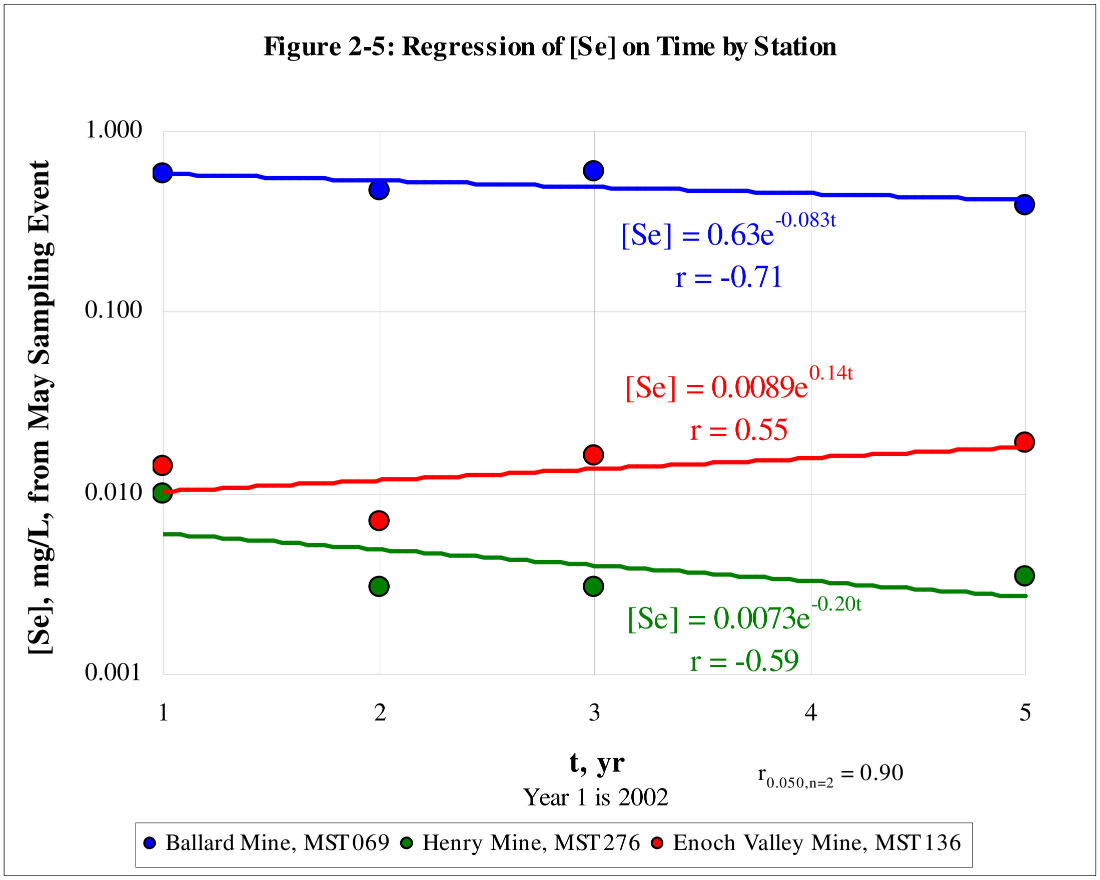


Figure 2-5: Regression of [Se] on Time by Station
[Se], mg/L, from May Sampling Event
1.000
0.100
0.010
0.001
[Se] = 0.63e^-0.083t
r = -0.71
[Se] = 0.0089e^0.14t
r = 0.55
[Se] = 0.0073e^-0.20t
r = -0.59
1
2
3
4
5
t, yr
Year 1 is 2002
r0.050,n=2 = 0.90
Ballard Mine, MST069
Henry Mine, MST276
Enoch Valley Mine, MST136

3.0 INVESTIGATION OBJECTIVES

The program objectives of the SIs for P4's Enoch Valley, Henry, and Ballard mines were formulated in accordance with the work plan rationale and data quality objectives (DQOs) process documented in Section 3.0 of the PjtWPs (MWH 2004a) and is also located in this document as Appendix O. Please note, that although this appendix indicates specific reference to Enoch Vally Mine, it is applicable to Henry and Ballard Mines as well. As a general objective, the data collection process is to provide those data that are necessary to evaluate among and select a removal action alternative in the EE/CA process. The amount of such data to be collected will be what is sufficient to conduct such evaluation and selection. The scope of work for the EE/CA is detailed in the EE/CA work plan (MWH, 2004b). Data are being collected to support risk management decisions and the data collected should be of sufficient quality (e.g., adequate spatial coverage, low enough detection limits, etc.) to determine exposures during the risk assessment.

The program objectives are detailed programmatically in Section 3.0 of the program field sampling plan (PgmFSP) (MWH, 2004d) and a presentation of objectives on a mine-specific basis can be found in Section 3.3 of the individual PjtWPs (MWH, 2004a) also located in appendix O.

The specific program work breakdown structure for the SIs is presented in the PgmFSP (MWH, 2004d) Table 3-1, *Program Work Breakdown Structure Tasks, Subtasks, and Activities*. The SI program tasks in Table 3−1 are also described in Section 4.0 of each individual PjtWP (MWH, 2004a). A timeline illustrating all site characterization activities conducted to date can be found in the form of a series of medium specific data and data gap summaries location in appendix K.

4.0 BACKGROUND CALCULATIONS AND BENCHMARKS

This section provides an interim evaluation of the program (region-specific) background and discusses preliminary risk-based benchmarks (PRBB) utilized in the SI-ES.

Background was calculated for each constituent of potential concern (COPC) and media using the approved protocol as detailed in *A Functional Upper Bound of Background*, of the Program Quality Assurance Plan (PgmQAP) included within the SAP—(MWH, 2004d) and also located herein as appendix P. The resulting media-specific background number is referred to as the preliminary FUBOB (functional upper bound of background). Please see Appendix M for further discussion on the statistical processes involved in the calculation of the preliminary FUBOB and for the comments and concerns the agencies put forth regarding this statistic. Please note that any further discussion of FUBOBs within this document will be rendered preliminary.

COPC analytes are based on the analyte list agreed upon in the AOC, with slight adjustments made for the approved 2004 analyte list listed in the Field Sampling Plan included within the SAP—(MWH, 2004d). COPC analytes are summarized in Table 4-1.

The FUBOB was calculated (by media) using all available programmatic background data. All data was validated in accordance with the PgmQAP. The data deliverable containing the validated 2004 data and the validation reports was originally submitted April 5, 2005 (MWH, 2005a). A revised document was submitted September 20, 2006.

Table 4-1
Constituents of Potential Concern from the
Approved 2004 Site Investigation Field Sampling Plan[a]

Analyte	Surface Water	Ground-water[b]	Sediment	Salmonid Fish	Forage Fish	Benthic Macro-invertebrates	Riparian Soil	Riparian Vegetation
	Basis							
Selenium	Unfiltered	Filtered / Unfiltered	Total	Total	Total	Total	Total	Total
Cadmium	Filtered	Filtered / Unfiltered	Total	Total	Total	NA	Total	Total
Chromium	NA	Filtered / Unfiltered	Total	NA	NA	NA	Total	NA
Copper	NA	NA	NA	NA	NA	NA	Total	Total
Molybdenum	NA	NA	NA	NA	NA	NA	Total	Total
Nickel	Filtered	Filtered / Unfiltered	Total	Total	Total	NA	Total	NA
Vanadium	Filtered	Filtered / Unfiltered	Total	Total	Total	NA	Total	NA
Zinc	Filtered	Filtered / Unfiltered	Total	Total	Total	NA	Total	Total

[a] *Comprehensive Site Investigation, Sampling and Analysis Plan,* Final, P4 Production Southeast Idaho Mine-Specific Selenium Program. Prepared for P4, April 2004.
[b] Analyses were performed on unfiltered samples for receptor samples and filtered samples for monitoring samples. See Section 6.3.7 of the 2004 FSP for additional discussion.

Appendix A, *Censored Historical Background Data,* includes tables of background data by media. *Uncensored Historical Background Data* is provided in Appendix B. The censored data from Appendix A is the data that was used to create the FUBOBs. Since we have been instructed to use censored data, censored results have been replaced by RL/2. The results from each Phase I SI medium (investigation) are compared to the respective FUBOB in Section 5 below. Per good statistical practice, all values, outliers or not, are included in calculations. Outliers may only be omitted if there is a priori knowledge of the invalidity of a given datum or else one risks biasing the data and resulting calculation.

Table 4-3 provides the FUBOB, alternative background statistics, and all information needed to calculate any background statistic for each target element by environmental medium. The number of sampling events and the number of samples are tabulated, along with the percentage of these samples that are censored (i.e., results are below the respective reporting limit, RL; in such situations, RL/2 is substituted for purposes of statistical calculations). Whether there is a statistically significant difference between the sampling events is noted. If none exists, the data from all events are combined into a single data set with degrees of freedom adjusted to account for how many degrees of freedom were lost in the test of significance between events (and, as appropriate, seasons). The test of significance used is the nonparametric (i.e., distribution-free) Kruskal-Wallis test (Addinsoft, 2006, XLSTAT v.2006.4).

The null hypothesis of distributional form is 4-parameter lognormal (4LN). Such a distribution is characterized by a mean, standard deviation, lower bound, and upper bound. If the upper bound is found to be so far above the highest value observed that it can be effectively regarded as infinity, then the distribution is simplified to a 2-parameter lognormal form (2LN). In this distribution the lower bound is zero, and there is no upper bound. In both cases the transformed values are normally distributed. The transformation for the 2LN distribution is:

$$y = \ln(x),$$

where x is a sample value and y is the transformed sample value. The transformation for the 4LN distribution is:

$$y = \ln\left[\frac{x - \hat{\lambda}}{\hat{\upsilon} - x}\right],$$

where $\hat{\lambda}$ is the estimated lower bound of the population, and $\hat{\upsilon}$ is the estimated upper bound of the population. As a physical constraint, $\hat{\lambda}$ cannot be lower than 0, and $\hat{\upsilon}$ cannot be greater than 1,000,000 parts per million (whether mg/L or mg/kg). The back-transformations for these two distributions are, respectively:

$$x = e^{y}$$

and

$$x = \frac{\hat{\upsilon}e^{y} + \hat{\lambda}}{1+e^{y}}.$$

The estimate of the sample median, $\hat{p}_{0.500}$, is provided. So are the transformed sample mean (also known as the estimate of the population sample mean of the transformed values, $\hat{\mu}_{T}$, sample standard deviation of the transformed values, s_{T}, and estimated population standard deviation of the transformed values, $\hat{\sigma}_{T}$. The difference between s_{T} and $\hat{\sigma}_{T}$ is that the sample standard deviation is an asymptotically unbiased estimator of the true population standard deviation (unlike the sample mean, which is an unbiased estimator of the true population mean). Thus, a correction factor needs to be applied to sample standard deviations from small datasets. These correction factors can be found tabulated in *Documenta Geigy* for sample sizes from 2 to 101; MWH has developed an Excel spreadsheet, available upon request, which will estimate the values from this table.

The values $\hat{\mu}_{T}$ and s_{T} are used to calculated confidence bounds of high-end quantiles, $p_{0.900,0.900}$, $p_{0.950,0.950}$, or the FUBOB, $p_{0.999,0.050}$, which respectively denote the 90th percentile defined with 90 percent confidence, the 95th percentile defined with 95 percent confidence, and the 99.9th percentile defined with 5 percent confidence. The values $\hat{\mu}_{T}$ and $\hat{\sigma}_{T}$ are used to estimate $\hat{\mu}$ and $\hat{\sigma}$, the estimates of the true mean and standard deviation on the untransformed scale. These parameters can be calculated for a 2-parameter lognormal distribution, but the formula for calculating them for the 4-parameter lognormal distribution is rather daunting; thus, for this distribution, it is easier to estimate the values by simulation.

Upper 80 percent and 95 percent confidence bounds of the mean, $\hat{\mu}_{0.800}$ and $\hat{\mu}_{0.950}$, are estimated through nonparametric Studentized bootstrapping. The USEPA prefers this method to parametric calculation because it avoids absurdly high estimates often encountered for lognormal distributions.

The minimum and maximum observations are provided, min and max. The value max_{obs} differs from max in that max_{obs} cannot be censored.

While alternative confidence bounds on alternative high-end quantiles are displayed, the FUBOB remains the best functional upper bound of background given that it was designed to perform best under typical conditions.

Once again the degrees of freedom, ν, are not necessarily set equal to the typical univariate n-1. This is because degrees of freedom are lost by testing for differences between sampling events. When such differences are found then the effective sample size become simply the number of events.

Background stations are either "programmatic background" and are not impacted by any phosphate mine, or "project specific background" and are not impacted by any P4 Production mine. Please note that background is not being used as a factor to screen out contaminants or media from the risk assessment.

For surface water, and all media for which surface water station locations are used (i.e., all other media except upland soil and upland vegetation), background stations were selected from the large set of stations established to ensure that all potential impacts from a Monsanto mine were characterized. Stations were placed both downstream and upstream of all stream junctions, and of the mines themselves. All those stations located upstream of not only Monsanto's phosphate mines, but all other phosphate mines, as well, are defined as regional background stations. It is these regional background stations (programmatic background) that are used to characterize background condition. There are currently eight such background stations that are routinely sampled during each surface water sampling event:

- MRV017, Blackfoot Reservoir delta at Meadow Creek;
- MST235, Meadow Creek above Blackfoot Reservoir;
- MST049, Little Blackfoot River above Reese Creek;
- MST254, Little Blackfoot River upstream of Henry cutoff road;
- MST093, North Fork Wooley Valley Creek above Ballard Mine;
- MST101, Caldwell Creek below Phosphoria Formation outcrop;
- MST236, Stewart Creek above Diamond Creek; and,
- MST237, Timber Creek above Diamond Creek.

This is a subset of the background stations approved by the interagency/industry phosphate working group for the regional investigation. Only those background stations located in the central district, the one in which Monsanto's three mines are located, were retained for Monsanto's mine-specific program. There are other Monsanto-specific background stations that are above a Monsanto mine but below another phosphate mine. Those are regarded as mine-specific background stations (project specific) and are not used to characterize regional background conditions.

There are no background surface water wells—at least not now. Thus, background surface water is being used as a surrogate for background groundwater.

For upland media, six Phosphoria Formation outcrops and one topsoil stockpile derived from the Enoch Valley Mine in the central district are used to characterize background conditions. The outcrops, the dates they were sampled, and under what program, are listed below:

- Caldwell Creek outcrop—July 1998 for the Idaho Mining Association;
- South Rasmussen outcrop—July & August 2000 for Monsanto;
- Enoch Valley Mine topsoil stockpile—July & August 2000 for Monsanto;
- Upper Diamond Creek outcrop—August 2001 for Monsanto;
- Stewart Creek outcrop—August 2001 for Monsanto;
- Slug Valley outcrop—August 2001 for Monsanto; and,
- Trail Canyon outcrop—August 2001 for Monsanto.

Three outcrops were sampled for IMA, one in each of the three districts the study area is divided into, but significant differences were observed between districts. Thus, for Monsanto only the Caldwell Creek outcrop data are included to represent central district background conditions. All of the other six outcrops and stockpile are also located in this district (i.e., the upper Blackfoot River watershed).

The PRBBs are utilized in the SI-ES to evaluate the Phase I SI data. Site-specific risk-based benchmarks will be developed as part of the risk assessment during the EE/CA. The PRBBs are compared to the Phase I SI data by medium below in Section 5.0. The sources of the PRBBs are detailed below by medium.

- Surface Water— Preliminary risk-based benchmarks for surface water are as follows (those which require hardness-adjusted benchmarks are presented assuming 100 mg/L hardness, but are compared individually against their hardness-specific benchmark):
    - Cadmium, selenium, chromium, nickel, and zinc PRBBs are the IDEQ's chronic coldwater biota standards IDAPA (2006).
    - Vanadium PRBB is the preliminary remediation goal-ecological endpoints benchmark recommended by ORNL (1996).
- Sediment—Preliminary risk-based benchmarks for sediment are as follows:
    - Selenium PRBB is the toxicity threshold as recommended by Skorupa (1998).
    - Cadmium, chromium, and nickel PRBBs are the toxicity threshold (probable effects concentration) as recommended by MacDonald (2000).
    - Vanadium PRBB is the lowest effect level (LEL) recommended by Thompson et. al. (2005).
    - Zinc PRBB is the toxicity threshold (threshold effects concentration) as recommended by MacDonald (2000).
-
- Salmonids—Preliminary risk-based benchmarks for salmonids are as follows:
    - The USEPA's draft chronic criterion for selenium is 7.91 mg/kg dw on a whole body basis. The IMA salmonid data, however, are for fillet—i.e., muscle tissue. Appendix H of the agency's draft criteria document (USEPA, 2004, *Draft Aquatic Life Water Quality Criteria for Selenium*, EPA-822-D-04-001, Office of Water) provides the following fish tissue data that can be used to generate the required conversion:

Table 4-2 Fish Tissue Selenium Concentrations mg/kg dw	
muscle	whole body
2.05	1.95
20.55	22.85
1.9	2.45
2.25	1.95
3.5	3.5
6.9	6.15
17.55	15.45
44.7	26.45
12.45	11.85
39.6	30.6
3.35	3.35
3.2	2.3
5.25	6.3
6.1	5.3
12.45	12
18.6	13
7.75	8.35
15.05	17.35
3.5	3
4.6	3.3
5.4	5.1

The data are plotted and a power regression fit as shown in Figure 4-1. With n = 21 and $\nu = 19$, $|r_{0.050}| = 0.433$; thus, the above regression is significant. Entering the whole body proposed criterion of 7.91 mg/kg dw and solving for the corresponding muscle concentration yields 8.8 mg/kg dw.

- No benchmarks were identified for the other analytes (cadmium, nickel, vanadium, and zinc).

- Forage Fish—Preliminary risk-based benchmarks for forage fish are as follows:

  - Selenium PRBB represents the proposed fish tissue quality draft criterion by USEPA (2004).

  - No benchmarks were identified for the other analytes (cadmium, nickel, vanadium, and zinc).

- Benthic Macroinvertebrates—The preliminary risk-based benchmark for selenium in benthic macroinvertebrates is from Lemly (2002).

- Riparian and Upland Soil—Preliminary risk-based benchmarks for riparian and upland soils are derived from maximum tolerance levels (MTL) published in National Research Council of the National Academies (NRC) (NRC, 2005). Each MTL was multiplied by 23, which represents a 95th percentile estimate of the fraction of a dry-weight diet for pastured dairy cattle that is incidentally ingested soil. Soil ingestion rate information is from Fries (1982).

- Riparian Vegetation—Preliminary risk-based benchmarks for riparian vegetation are maximum tolerance levels published in NRC (2005). The maximum tolerable level is the dietary level that, when fed for a defined period of time, will not impair animal health and performance (NRC, 2005).

Appendix L contains further discussion on PRBBs, which includes a table documenting PRBBs that are available for use as potential ecological or human health benchmarks. Sources not listed in Section 6.0 can be located in the footnotes of the PRBB table in Appendix L.

At the request of IDEQ, table 4-4 below shows a side-by-side comparison of the programmatic background data collected in 2004 with the PRBBs used in tables 5-1 thru 5-3, and the pertinent statistics from table 4-3.

Figure 4-1
Regression of [Se]: Whole Body v. Muscle

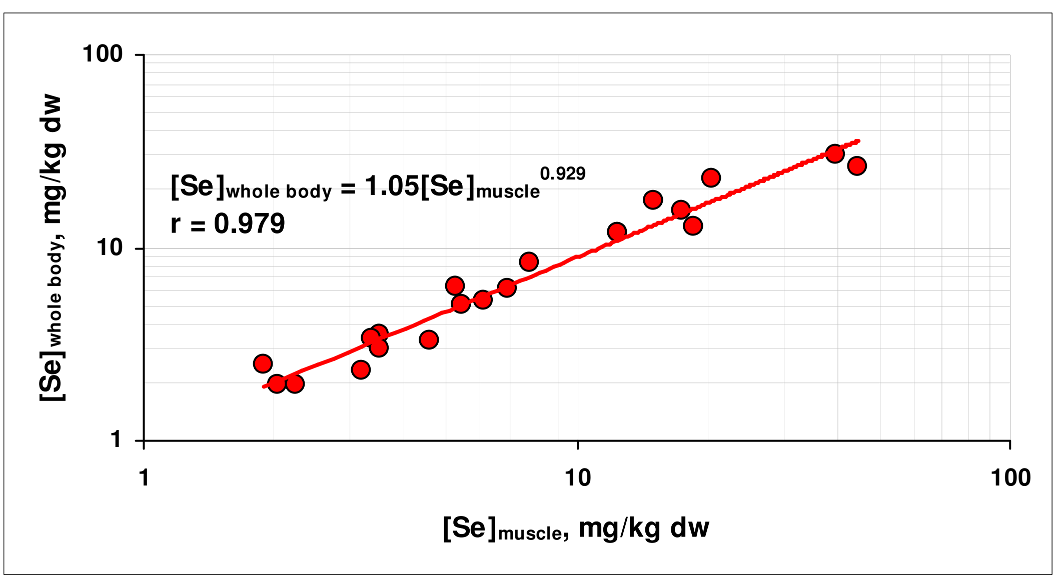


Table 4-3: Background Statistics

Medium	Element	Sampling				Distribution										Observations			Upper Tolerance Bounds		FUBOB		Notes
							mg/L									mg/L							
		events	samples	% non-detect	differences	form	$\hat{p}_{0.500}$	$\hat{\mu}_T$	s_T	$\hat{\sigma}_T$	$\hat{\mu}$	$\hat{\sigma}$	$\hat{\mu}_{0.800}$	$\hat{\mu}_{0.950}$	$\hat{\lambda}$	$\hat{\upsilon}$	min	max	max_{obs}	$p_{0.900,0.900}$	$p_{0.950,0.950}$	$p_{0.999,0.050}$	ν	
Surface Water	Se	8	36	94	yes	2LN	0.00055	-7.5	0.62	0.65	0.00068	0.00049	0.0011	0.0016	0	n/a	< 0.00070	0.0018	0.0018	0.0022	0.0040	0.0020	7	transformed data are not quite normal, but are assumed to be so
	Cd	5	31	100	yes	4LN	0.00011	-0.84	2.93	3.1	0.00013	0.000077	0.00019	0.00024	0.000048	0.00026	< 0.00010	< 0.0011	n/a	0.00026	0.00026	0.00026	4	
	Cr	2	9	89	yes	2LN	0.0012	-6.7	2.04	2.6	0.031	0.79	0.0074	0.0074	0	n/a	< 0.00020	< 0.010	0.00030	1,400,000	2.10E+20	0.021	1	insufficient data to test distributional form, thus 2LN assumed; $p_{0.900,0.900}$ and $p_{0.950,0.950}$ are obviously nonsensical; the FUBOB was designed to prevent this instead of such nonsense; a 4-parameter distribution would prevent such nonsense, too, but the resulting values would likely both be equal to 1,000,000; the upper confidence bounds of the mean were determined by bootstrapping a dataset of size 2, thus, the values are not very reliable
	Ni	2	15	100	yes	2LN	0.0025	-6.0	0.45	0.56	0.0029	0.0017	0.0042	0.0042	0	n/a	< 0.00020	< 0.0050	n/a	0.25	330	0.0047	1	runoff only (significant seasonal difference); insufficient data to test distributional form; thus, 2LN assumed
		1	6	100	n/a	n/a	0.014	n/a	n/a	n/a	0.014	0	0.014	0.014	n/a	n/a	< 0.028	< 0.028	n/a	0.014	0.014	0.014	5	baseflow only (significant seasonal difference); given that the entire dataset is censored, tabulated values have little-to-no meaning
	V	3	21	71	yes	4LN	0.0023	-2.6	1.76	2.0	0.0031	0.0018	0.0039	0.0043	0.0017	0.010	< 0.00048	0.011	0.011	0.0099	0.010	0.0065	2	
	Zn	2	15	87	yes	4LN	0.0017	-2.9	3.21	0.0042	0.0040	0.0042	0.0061	0.0084	0.00096	0.015	< 0.0020	0.014	0.014	0.014	0.015	0.015	12	runoff only (significant seasonal difference, but no significant year-to-year difference)
		1	6	100	yes	n/a	0.038	n/a	n/a	n/a	0.038	0	0.038	0.038	n/a	n/a	< 0.076	< 0.076	n/a	0.038	0.038	0.038	4	baseflow only (significant seasonal difference); given that the entire dataset is censored, tabulated values have little-to-no meaning
							mg/kg dw									mg/kg dw							
Sediment	Se	5	25	56	yes	2LN	0.68	-0.39	0.45	0.48	0.76	0.39	0.91	1.1	0	n/a	0.13	< 1.4	1.3	2.3	4.5	1.6	4	
	Cd	5	28	0	no	2LN	1.3	0.29	0.84	0.85	1.9	2.0	4.3	5.4	0	n/a	0.22	4.4	4.4	5.6	9.3	10	23	
	Cr	3	21	4.8	no	4LN	21	0.07	0.70	0.71	21	6.4	33	37	0	40	11	32	32	32	34	34	18	
	Ni	4	23	4.3	no	2LN	16	2.8	0.60	0.61	20	13	39	50	0	n/a	< 6.3	51	51	47	69	69	19	
	V	4	23	0	no	2LN	24	3.2	0.38	0.39	26	10	43	50	0	n/a	11	47	47	47	59	59	19	
	Zn	4	23	8.7	no	4LN	77	0.37	1.26	1.3	74	32	150	170	0	130	18	120	120	120	130	130	19	
Benthic Macroinvertebrates	Se	3	11	55	no	2LN	2.1	0.75	0.76	0.79	2.9	2.7	5.2	6.4	0	n/a	0.50	< 12	4.1	11	21	11	8	
	Cd	2	3	0	no	2LN	3.6	1.3	0.12	0.15	3.7	0.55	4.1	4.2	0	n/a	3.2	4.0	4.0	12	85	4.3	1	
Forage Fish	Se	2	6	17	no	2LN	3.3	4.9	0.37	0.40	4.2	3.1	6.0	7.8	0	n/a	< 2.4	7.6	7.6	360	620	11	4	
	Cd	2	6	33	no	2LN	0.21	-1.6	1.61	1.7	0.91	3.8	1.9	2.7	0	n/a	< 0.070	2.8	2.8	17	180	4.3	4	
	Ni	1	4	25	n/a	2LN	2.0	0.70	2.31	2.5	46	1,000	17	21	0	n/a	< 0.19	24	24	3,200	290,000	120	3	
	V	1	4	0	n/a	2LN	0.73	-0.31	0.22	0.24	0.75	0.18	0.87	1.0	0	n/a	0.57	0.95	0.95	1.5	2.3	1.1	3	
	Zn	1	4	0	n/a	2LN	130	4.9	0.37	0.40	140	59	170	200	0	n/a	78	180	180	420	870	250	3	
Salmonids	Se	1	2	0	n/a	2LN	3.4	1.2	0.25	0.32	3.5	1.2	4.6	4.6	0	n/a	2.8	4.0	4.0	43	2,400	4.8	1	
	Cd	1	2	0	n/a	2LN	0.36	-1.0	0.12	0.15	0.36	0.054	0.42	0.42	0	n/a	0.33	0.39	0.39	1.2	8.4	0.42	1	
Riparian Soil	Se	2	11	36	yes	2LN	0.72	-0.33	0.73	0.91	1.1	1.2	1.6	1.6	0	n/a	< 0.50	1.5	1.5	1,300	150,000,000	2.0	1	insufficient data to test distributional form, thus 2LN assumed; $p_{0.900,0.900}$ and $p_{0.950,0.950}$ are obviously nonsensical; the FUBOB was designed to prevent this instead of such nonsense; a 4-parameter distribution would prevent such nonsense, too, but the resulting values would likely both be equal to 1,000,000; the upper confidence bounds of the mean were determined by bootstrapping a dataset of size 2, thus, the values are not very reliable
	Cd	1	8	0	n/a	2LN	1.4	0.35	0.71	0.73	1.8	1.6	3.3	4.4	0	n/a	0.53	4.4	4.4	6.9	14	6.1	7	
	Cr	2	11	0	yes	2LN	34	3.5	0.43	0.54	39	23	57	57	0	n/a	14	56	56	2,800	2,700,000	62	1	insufficient data to test distributional form, thus 2LN assumed; $p_{0.900,0.900}$ and $p_{0.950,0.950}$ are obviously nonsensical; the FUBOB was designed to prevent this instread of such nonsense; a 4-parameter distribution would prevent such nonsense, too, but the resulting values would likely both be equal to 1,000,000; the upper confidence bounds of the mean were determined by bootstrapping a dataset of size 2, thus, the values are not very reliable
	Cu	2	11	0	no	4LN	16	2.0	0.52	0.53	15	4.7	23	26	0	22	5.3	21	21	21	21	21	9	
	Mo	1	8	88	n/a	2LN	0.78	-0.25	0.31	0.33	0.82	0.28	1.1	1.3	0	n/a	< 1.4	1.7	1.7	1.5	2.1	1.5	7	
	Ni	2	11	9.1	no	2LN	15	2.7	0.51	0.52	17	9.6	26	30	0	n/a	< 8.4	27	27	43	66	45	9	
	V	2	11	9.1	yes	2LN	38	3.7	0.31	0.39	42	17	57	57	0	n/a	< 20	55	55	920	130,000	60	1	
	Zn	2	11	0	no	2LN	74	4.3	0.52	0.54	86	50	140	170	0	n/a	24	160	160	220	340	230	9	
Riparian Vegetation	Se	3	13	54	no	2LN	0.95	-1.3	0.58	0.60	1.1	0.75	0.57	0.80	0	n/a	0.094	0.90	0.90	0.86	1.4	0.95	10	
	Cd	3	13	0	no	2LN	0.26	-1.3	0.86	0.89	0.39	0.43	0.83	1.1	0	n/a	0.080	0.90	0.90	1.5	3.0	1.7	10	
	Cu	2	11	73	yes	2LN	4.4	1.5	0.10	0.12	4.4	0.53	5.0	5.0	0	n/a	3.7	< 9.3	4.3	12	61	5.0	1	
	Mo	2	11	27	no	2LN	0.89	-0.12	0.68	0.70	1.1	0.90	2.2	2.8	0	n/a	0.71	2.6	2.6	3.6	6.4	3.8	9	
	Ni	1	3	0	n/a	2LN	0.59	-0.53	0.34	0.39	0.64	0.26	0.88	0.88	0	n/a	0.48	0.88	0.88	2.5	8.0	1.0	2	
	V	1	3	0	n/a	2LN	0.92	-0.08	0.69	0.78	1.3	1.1	1.9	2.1	0	n/a	0.52	2.0	2.0	17	180	2.9	2	
	Zn	2	11	0	no	2LN	30	3.4	0.45	0.46	34	16	54	65	0	n/a	12	64	64	77	110	80	9	
Upland Soil	Se	7	26	3.8	yes	2LN	1.5	0.43	0.82	0.86	2.2	2.3	3.5	4.4	0	n/a	< 0.40	3.6	3.6	10	25	8.1	6	
Upland Vegetation	Se	7	26	0	yes	2LN	0.21	-1.6	0.79	0.82	0.29	0.29	0.58	0.81	0	n/a	0.020	1.2	1.2	1.3	3.1	1.0	6	

Notes:

FUBOB: functional upper bound of background.

N: normal distribution.

2LN: 2-parameter lognormal distribution.

4LN: 4-parameter lognormal distribution.

$\hat{p}_{0.500}$: estimated population median (i.e., 50th percentile).

$\hat{\mu}_T$: estimated mean of the population mean of the trasnformed values.

s_T : sample standard deviationof the transformed values.

$\hat{\sigma}_T$: estimated population standard devation of the transformed values.

$\hat{\mu}$: estimated population mean.

$\hat{\sigma}$: estimated population standard deviation.

$\hat{\mu}_{0.800}$ Mean defined with 80% confidence

$\hat{\mu}_{0.950}$ Mean defined with 95% confidence

$\hat{\lambda}$: estimated population lower bound.

$\hat{\upsilon}$: estimated population upper bound.

max_{obs} : maximum observed uncensored value.

$p_{0.900,0.900}$: 90.0th percentile defined with 90% confidence.

$p_{0.950,0.950}$: 95.0th percentile defined with 95% confidence.

$p_{0.999,0.050}$: 99.9th percentile defined with 5% confidence.

mg/L: aqueous concentration units, milligrams per liter.

mg/kg dw: solid concentration units, milligrams per kilogram on a dry-weight basis.

n/a: not applicable.

ν: degrees of freedom. Please note that whether the degrees of freedom are n-1 or based on the number of events depends on whether the events are statistically different from one another. If they are, the number of events becomes the number of samples.

Table 4-4: Background Data and Statistical Comparison Table																																					
			Surface Water[l]						***Sediment[k]***						***Benthic[o] Macroinvertebrate***	***Forage Fish[n] (whole-body)***					***Salmonid Fish[m] (fillet)***		***Riparian Soil[h]***								***Riparian Vegetation[i]***					***Upland Soil[h]***	***Upland Veg[i]***
			May 2004						**May 2004**						**June 2004**	**May 2004**					**May 2004**		**September 2004**								**September 2004**					**2004**	**2004**
Feature	***Program Background Station Name***	***Station***	**Unfiltered (mg/L)**	**Filtered (mg/L)**					**Total (mg/kg dw)**						**Total (mg/kg dw)**	**Total (mg/kg dw)**					**Total (mg/kg dw)**		**Total (mg/kg dw)**								**Total (mg/kg dw)**					**Total (mg/kg dw)**	**Total (mg/kg dw)**
		Analytes	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***	***Se***	***Se***
Preliminary Risk-Based Benchmark			0.0050	0.00060[g]	0.074	0.052[g]	0.020	0.12[g]	4.0	5.0	110	49	35	120	3.0	7.9	-	-	-	-	8.8	-	115	230	2300	920	115	2300	1150	11500	5.0	10	40	5.0	500	115	5.0
Preliminary Functional Upper Bound of Background[j], $P_{0.999,\ 0.050}$			0.0020	0.00026	0.021	0.0047	0.0065	0.015	1.6	10	34	69	59	130	11	11	4.3	120	1.1	250	4.8	0.42	2.0	6.1	62	21	1.5	45	60	230	0.95	1.7	5.0	3.8	80	8.1	1.0
Upper Tolerance Bound, $P_{0.900,0.900}$			0.0022	0.00026	1,400,000	0.25	0.0099	0.014	2.3	5.6	32	47	47	120	11	360	17	3,200	1.5	420	43	1.2	1,300	6.9	2,800	21	1.5	43	920	220	0.86	1.5	12	3.6	77	10	1.3
Upper Tolerance Bound, $P_{0.950,0.950}$			0.0040	0.00026	2.10E+20	330	0.010	0.015	4.5	9.3	34	69	59	130	21	620	180	290,000	2.3	870	2,400	8.4	150,000,000	14	2,700,000	21	2.1	66	130,000	340	1.4	3.0	61	6.4	110	25	3.1
$\hat{\mu}_{0.800}$: Mean Defined with 80% Confidence			0.0011	0.00019	0.0074	0.0042	0.0039	0.0061	0.91	4.3	33	39	43	150	5.2	6.0	1.9	17	0.87	170	4.6	0.42	1.6	3.3	57	23	1.1	26	57	140	0.57	0.83	5.0	2.2	54	3.5	0.58
$\hat{\mu}_{0.950}$: Mean Defined with 95% Confidence			0.0016	0.00024	0.0074	0.0042	0.0043	0.0084	1.1	5.4	37	50	50	170	6.4	7.8	2.7	21	1.0	200	4.6	0.42	1.6	4.4	57	26	1.3	30	57	170	0.80	1.1	5.0	2.8	65	4.4	0.81
Blackfoot Reservoir Delta	At Meadow Creek	MRV017	< 0.0010	< 0.00010	NA	< 0.0050	0.0023	< 0.0040	< 0.50	0.39	14	9.1	16	26	NS	3.0	0.072<x<0.096	1.8	0.81	160	NS	NS	< 0.50	0.53	14	5.3	< 1.4	< 8.4	< 20	24	< 0.50	0.080	< 9.3	< 0.78	38	NS	NS
Meadow Creek	Above Blackfoot Reservoir	MST235	< 0.0010	< 0.00020	NA	< 0.0050	0.0022	< 0.0040	< 0.50	0.22	< 13	< 6.3	11	18	< 12	2.7	0.065<x<0.088	3.8	0.57	130	NS	NS	< 0.50	0.60	22	11	< 1.4	10	23	42	< 0.50	0.11	< 9.3	< 0.78	12	NS	NS
Little Blackfoot River	Above Reese Creek	MST049	< 0.0010	< 0.00010	NA	< 0.0050	0.00065	< 0.0020	< 0.50	1.2	26	16	29	76		NS	NS	NS	NS	NS	NS	NS	< 0.50	1.4	25	15	< 1.4	16	29	77	< 0.50	0.14	< 9.3	2.6	28	NS	NS
	Upstream of Henry cutoff road	MST254[a]	< 0.0010	< 0.00010	NA	< 0.0050	0.00055	< 0.0027	< 0.50	0.78	20	13	23	75	< 1.3	< 2.4	< 0.24	24	0.95	180	NS	NS	< 0.50	1.2	21	12	< 1.4	13	25	60	< 0.50	0.12	< 9.3	0.91	23	NS	NS
North Fork Wooley Valley Creek	Above Ballard Mine	MST093[f]	< 0.0010	< 0.00020	< 0.00020	< 0.0050	0.0062	< 0.0040	< 0.50	1.8	28	20	38	93	< 8.3	NS	NS	NS	NS	NS	NS	NS	0.50	2.7	23	21	< 1.4	15	30	110	< 0.50	0.35	< 9.3	1.6	27	NS	NS
Caldwell Creek	Below Phosphoria Formation outcrop	MST101[f]	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	< 0.0020	0.70	1.8	22	21	26	90	< 2.9	NS	NS	NS	NS	NS	NS	NS	0.50	1.8	26	19	< 1.4	21	33	99	0.80	0.60	< 9.3	2.4	64	NS	NS
Stewart Creek	Above Diamond Creek	MST236[f]	< 0.0010	< 0.00010	0.00030	< 0.00020	< 0.00048	0.014	< 0.60	3.1	32	24	37	120	< 4.2	NS	NS	NS	NS	NS	NS	NS	0.70	4.4	43	19	1.7	27	52	160	< 0.50	0.90	< 9.3	0.94	52	NS	NS
Timber Creek	Above Diamond Creek	MST237	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	0.014	< 0.60	0.90	20	18	26	66	< 4.0	3.3	0.060<x<0.11	< 0.19	0.67	78	NS	NS	0.70	1.4	27	16	< 1.4	18	35	91	< 0.50	0.34	< 9.3	< 0.78	28	NS	NS

[a] Average of the QA replicate samples reported for May 2004 sediment, surface water results.

[f] All benthic macroinvertebrate sampler results at each station were mathematically averaged except those stations footnoted (f) were composited prior to laboratory analysis.

[g] Hardness-water quality criterion calculated on an assumed 100 mg/L $CaCO_3$ hardness. Highlighted stations are those stations that exceed their station-specific criterion based on station-specific hardness.

[h] Preliminary risk-based benchmarks for riparian soil are derived from MTL's published in NRC (2005). Each MTL was multiplied by 23, which represents a 95th percentile estimate of the fraction of a dry-weight diet for pastured dairy cattle that is incidentally ingested soil. Soil ingestion rate information from Fries et al. (1982).

[i] Preliminary risk-based benchmarks for riparian vegetation are MTL's published in NRC (2005).

[j] preliminary FUBOBs calculated from all available background data for each media since 1997.

[k] The sources of the preliminary risk-based benchmarks for sediment are as follows. For selenium, value represents the toxicity threshold as recommended by Van Derveer and Canton (1997), San Joaquin Valley drainage Program (1990) and Lemly and Smith (1987) as cited in Skorupa, J., 1998, "Selenium," in P. L. Martin and D. E. Larsen (editors), Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. National Irrigation Water Quality Program Information Report No.3, Department of the Interior, pp. 139-184. For cadmium, chromium, and nickel, MacDonald, D. D., C. G. Ingersoll, and T. Berger, 2000, "Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems," Archives of Environmental Contamination and Toxicology, vol. 39, pp. 20 to 31, Probable Effects Concentration. For vanadium, lowest effect level recommended by Thompson et. al. (2005). For zinc, threshold effects doncentration recommended by MacDonald et. al. (2000).

[l] The sources of the preliminary risk-based benchmarks for surface water are the IDEQ's chronic coldwater biota standards (i.e., the USEPA's chronic water quality criterion, 40 CFR 131.36) for all analytes except vanadium. Vanadium, Oak Ridge National Laboratory, July 1996, "Preliminary Remediation Goals for Ecological Endpoints," United States Department of Energy, Office of Environmental Management.

[m] No preliminary risk-based benchmarks for salmonid fish were identified except for selenium. For selenium, the proposed USEPA fish tissue quality criterion of 8.8 mg/kg dw (fillet) was utilized.

[n] No preliminary risk-based benchmarks for forage fish were identified except for selenium. For selenium, the proposed USEPA fish tissue quality criterion of 7.9 mg/kg dw (whole-body) was utilized.

[o] The source of the preliminary risk-based benchmark for selenium in benthic macroinvertebrates is 3.0 mg/kg dw for food chain organisms as provided in Lemly, D.A., 2002, "Selenium Assessment in Aquatic Ecosystems, A guide for Hazard Evaluation and Water Quality Criteria", Springer-Verlag, New York.

NA - Not analyzed.

NE - Not electrofished, station was not electro-fished (i.e., not applicable for electro-fishing).

NS - Not sampled. For Fish investigations, the station was electro-fished, but no sample was obtained.

5.0 DATA EVALUATION AND DISCUSSION

This section provides an interim evaluation and discussion of the Phase I SI results programmatically by task, subtask, and activity. The Phase I SI results were provided in the *Phase I Site Investigation Summary Report* (MWH, 2005a). Refer to the aforementioned document for the validated data and data validation summaries by event-media for the analytical data. In addition, Appendix C—*Supplemental Surface Water Information*, presents Table C-1, *Surface Water Field Parameters*, and Table C-2, *Calculated Hardness-Dependent Criteria for Surface Water*.

The SI program tasks are described in Section 4.0 of each individual PjtWP (MWH, 2004a). The sampling locations, frequency, and schedule of tasks involving fieldwork are described in detail within Section 4.0 of the PgmFSP (MWH, 2004d) and the sample collection and analysis procedures of these tasks are described within Section 6.0 of the PgmFSP (MWH, 2004d).

The locations of sampling stations are shown in Figure 2-1, *Program Sampling Locations as well as the mine-specific detail maps shown in Figures 2-2, 2-3 and 2-4*.
Note, unless otherwise noted, all data in tables provided report censored data, i.e., non-detect results are reported as less-than the laboratory's reporting limit (< RL). All statistical evaluations, spatial wire diagrams, and chart plots utilize one-half the reporting limit (RL/2) for non-detect/censored results.

5.1 TASK 1: SURFACE WATER AND SEDIMENT INVESTIGATION

This task included two subtasks. Subtask 1b, discussed below, involved field sampling.

5.1.1 Subtask 1a— Investigation of Historical Irrigation Practices

P4 investigated historic irrigation practices by reviewing United States Geological Survey (USGS) topographic maps for un-naturally straight streams (i.e., possible irrigation ditches), reviewing aerial photographs, and by visual observation by field teams during the May 2004 sampling event.

No historic irrigation practices other than existing irrigation ditches were identified, therefore, historic irrigation practices do not present a potential impact on surface water or groundwater quality or flow.

5.1.2 Subtask 1b—Surface Water and Sediment Sampling

This subsection presents an evaluation of the surface water and sediment data through a tabulated comparison of each mine's data to COPC thresholds, and visually with spatial wire diagrams (SWDs) of flowing systems (i.e., no ponds are presented).

5.1.2.1 Data comparison to COPC thresholds

The tabulated Phase I SI results (by mine) are compared to the higher of either the PRBB or the FUBOB (background), both of which are analyte- and media- specific. Thresholds, refers to the PRBB and FUBOB. Both the PRBB and the FUBOB are provided in the table heading at the top of each page. Each table has two pages, the first page includes stream stations and the second page includes springs, seeps, ponds, and background stream stations.

Interpreting the tables, shading indicates an exceedance of the threshold and that the P4 mine has a reasonable potential to contribute to that exceedance. For example, the exceeded station result is downstream of a P4 mine (surface or subsurface hydrologically), or an exceedance increases along a longitudinal profile of a stream. Those exceedances bolded, but not shaded, are those stations that the P4 mine could not be reasonably expected to contribute to the exceedance. Site-specific risk-based benchmarks will be developed as part of the risk assessment during the EE/CA. Refer either to Figure 2-1, *Program Sampling Locations*, the mine-specific detail maps in Figures 2-2, 2-3 and 2-4, or the SWDs presented in Appendices D through G for a visual depiction of the stream/station network.

Please note that while some stations listed as pertaining to a particular mine may not visually look applicable, the selection rationale includes potentially impacted (downstream) stations as well as mine-specific background stations and program background stations (MWH, 2004a and MWH, 2004d). For example, while MST057, MST058, MST064, and MST276 may not appear to be affected by Enoch Valley Mine, they are relevant as mine-specific background stations to Enoch Valley Mine.

Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, and Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results* compare the tabulated Phase I SI aquatic and riparian media results (including surface water, sediment, salmonid fish, forage fish, benthic macroinvertebrates, riparian soil, and riparian vegetation) to the COPC thresholds indicated on the respective table. The comparison is discussed by mine below.

Table 5-1, Enoch Valley Mine--Aquatic and Riparian Media Censored Results[p]																																							
Feature	*Station Name*	*Station*	*Upstream*	*Surface Water*[l]						*Sediment*[k]						*Salmonid Fish*[m] *(fillet)*					*Forage Fish*[n] *(whole-body)*					*Benthic*[o] *Macroinvertebrate*	*Riparian Soil*[h]								*Riparian Vegetation*[i]				
				May 2004						May 2004						May 2004					May 2004					June 2004	September 2004								September 2004				
				Unfiltered (mg/L)	Filtered (mg/L)					Total (mg/kg dw)						Total (mg/kg dw)					Total (mg/kg dw)					Total (mg/kg dw)	Total (mg/kg dw)								Total (mg/kg dw)				
Streams and Reservoir Deltas		*Analytes*		*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Se*	*Cd*	*Cr*	*Cu*	*Mo*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cu*	*Mo*	*Zn*
Preliminary Risk-Based Benchmark				*0.0050*	*0.00060*[g]	*0.074*	*0.052*[g]	*0.020*	*0.12*[g]	*4.0*	*5.0*	*110*	*49*	*35*	*120*	*8.8*					*7.9*					*3.0*	*115*	*230*	*2300*	*920*	*115*	*2300*	*1150*	*11500*	*5.0*	*10*	*40*	*5.0*	*500*
preliminary Functional Upper Bound of Background[j], $P_{0.999,\ 0.050}$				*0.0020*	*0.00026*	*0.021*	*0.0047*	*0.0065*	*0.015*	*1.6*	*10*	*34*	*69*	*59*	*130*	*4.8*	*0.42*				*11*	*4.3*	*120*	*1.1*	*250*	*11*	*2.0*	*6.1*	*62*	*21*	*1.5*	*45*	*60*	*230*	*0.95*	*1.7*	*5.0*	*3.8*	*80*
Blackfoot River	Above Blackfoot Reservoir	MST232[d]		0.0020	< 0.00010	NA	< 0.0050	0.0011	< 0.0020	1.2	1.1	16	10	16	40	NS	NS	NS	NS	NS	9.5	0.043<x<0.097	4.0	0.54	120	10<x<14	< 0.50	2.0	30	8.4	< 1.4	15	31	71	< 0.50	0.055	< 9.3	2.1	9.3
	Below Woodall Mountain Creek	MST231[a]		0.0020	< 0.00020	NA	< 0.0050	0.0010	< 0.0040	< 0.50	0.69	< 13	6.7	9.7	24	NS	NS	NS	NS	NS	9.5	0.087<x<0.11	3.5	0.49	140	**27**	< 0.50	1.1	19	7.5	< 0.30	13	22	61	< 0.50	< 0.050	< 9.3	1.3	38
	Below Ballard Creek	MST019		0.0030	< 0.00020	NA	< 0.0050	0.00090	< 0.0040	0.70	1.2	20	7.7	17	31	NS	NS	NS	NS	NS	8.9	0.11	2.7	**1.3**	120	7.1	1.5	3.7	31	14	< 1.4	15	41	120	< 0.50	0.63	< 9.3	0.88	28
	Below State Land Creek	MST020[d]		0.0020	< 0.00010	NA	< 0.0050	0.00092	< 0.0020	< 0.50	1.5	31	13	30	45	NS	NS	NS	NS	NS	11	<0.11	1.4	0.69	230	3.4<x<7.5	1.7	1.1	28	11	< 1.4	16	31	80	< 0.50	0.093	< 9.3	< 0.78	44
	Above State Land Creek	MST230[a]		0.0027	< 0.00010	NA	< 0.0050	0.00091	< 0.0020	0.83	2.9	37	9.2	27	36	NS	NS	NS	NS	NS	9.0	0.11<x<0.16	1.4	0.78	**260**	**13**	1.9	0.91	20	7.7	< 1.4	13	22	60	< 0.50	0.060	< 9.3	< 0.78	28
	Below Trail Creek	MST021[a]		0.0023	< 0.00010	NA	< 0.0050	0.00093	< 0.0027	< 0.50	1.5	29	8.1	20	30	NS	NS	NS	NS	NS	9.5	0.14	1.6	**1.3**	150	10	1.2	1.6	32	14	< 0.30	22	33	100	< 0.50	< 0.050	< 9.3	< 0.78	19
	Below Wooley Valley Creek	MST022[d]		0.0030	< 0.00010	NA	< 0.0050	0.00087	< 0.0020	0.50	1.4	25	7.3	19	26	NS	NS	NS	NS	NS	**12**	0.12<x<0.16	1.5	0.80	180	4.2	0.93	1.9	25	9.3	< 1.4	13	26	63	< 0.50	0.29	< 9.3	< 0.78	25
	Below Dry Valley Creek, (1997 #20)	MST023		< 0.0010	< 0.00010	NA	< 0.0050	0.0018	0.0060	1.0	1.8	30	6.8	22	26	6.0	< 0.050	0.20	1.1	80	11	0.19<x<0.22	0.63	0.75	190	9.6	1.1	0.77	15	5.1	< 1.4	11	< 20	48	< 0.50	0.16	< 9.3	2.1	23
	Above Dry Valley Creek, (1997 #19)	MST024		0.0030	< 0.00010	NA	< 0.0050	0.00077	< 0.0020	0.80	1.5	25	8.7	23	34	NS	NS	NS	NS	NS	**14**	< 0.083	2.2	**2.1**	90	10	0.90	0.72	15	5.3	< 1.4	9.0	< 20	40	< 0.50	0.27	< 9.3	2.7	37
	Below Wooley Range Ridge Creek	MST025[e]		0.0020	< 0.00010	NA	< 0.0050	0.00086	< 0.0020	1.5	0.55	< 13	6.4	13	30	NS	NS	NS	NS	NS	11	0.17	1.4	1.1	160	5.2<x<7.9	0.93	1.0	17	7.0	< 1.4	11	< 20	51	< 0.50	0.40	< 9.3	1.4	32
	Above Wooley Range Ridge Creek	MST026		**0.0070**	< 0.00010	NA	< 0.0050	0.00087	< 0.0020	2.3	0.56	13	7.6	14	33	NS	NS	NS	NS	NS	1.4<x<1.8	0.080<x<0.12	4.3	0.64	90	1.9<x<6.1	0.80	2.4	28	8.8	< 1.4	15	27	83	< 0.50	0.23	< 9.3	2.1	21
	Below Angus Creek	MST027		**0.0080**	< 0.00020	NA	< 0.00040	0.00070	< 0.0040	1.3	0.58	14	7.8	15	32	6.1	<0.043	0.39	0.30	87	9.2	0.16	2.2	0.59	120	**12**	< 0.50	0.87	18	8.9	< 1.4	12	21	55	< 0.50	0.23	< 9.3	2.0	16
	Above Diamond Creek Rd.	MST028	X	0.0050	< 0.00020	NA	< 0.00040	0.00070	< 0.0040	0.90	0.50	13	7.9	14	30	NS	NS	NS	NS	NS	6.6	0.064<x<0.11	1.5	0.46	170	9.3	< 0.50	0.56	< 14	5.2	< 1.4	9.5	< 20	33	< 0.50	0.070	< 9.3	< 0.78	11
	Below Spring Creek	MST229	X	0.0050	< 0.00020	NA	< 0.00040	0.00070	< 0.0040	2.7	0.56	15	8.2	16	34	NS	NS	NS	NS	NS	**15**	0.028<x<0.10	2.2	0.57	160	**15**	1.0	1.3	22	10	< 1.4	26	26	120	< 0.50	0.060	< 9.3	< 0.78	16
	Above Spring Creek	MST029	X	< 0.0010	< 0.00020	NA	< 0.00040	0.00080	< 0.0040	< 0.50	0.37	15	7.4	16	24	NS	NS	NS	NS	NS	**12**	0.070<x<0.13	2.2	0.53	220	1.2	< 0.50	0.90	17	7.9	< 1.4	< 8.4	< 20	41	< 0.50	0.13	< 9.3	0.88	12
Little Blackfoot River	Above Blackfoot Reservoir	MST234[a]		< 0.0010	< 0.00020	NA	< 0.0050	0.00080	0.0040	1.5	0.94	24	15	17	93	NS	NS	NS	NS	NS	3.9	< 0.11	3.3	0.43	200	1.2<x<1.8	< 0.50	1.0	26	8.2	< 1.4	23	< 20	170	< 0.50	0.15	< 9.3	3.3	29
	Below Long Valley Creek	MST043[a]		< 0.0010	< 0.00010	NA	< 0.0050	0.0012	0.0040	1.7	0.90	25	14	22	88	NS	NS	NS	NS	NS	6.1	0.083<x<0.10	3.8	0.41	180	1.1<x<3.2	1.1	0.83	25	8.5	< 1.4	20	27	91	< 0.50	< 0.050	< 9.3	1.6	11
	Immediately below Henry Mine (1997 #24)	MST044[f]		< 0.0010	< 0.00010	NA	< 0.0050	0.0013	< 0.0020	1.1	1.4	36	11	29	68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 8.3	5.3	2.8	46	20	< 1.4	28	38	130	**7.9**	0.26	< 9.3	4.5	31
	Above Henry Creek (1997 #23)	MST045		< 0.0010	< 0.00010	NA	< 0.0050	0.0026	0.011	1.1	0.66	25	12	21	49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 6.3	1.5	0.92	28	11	< 1.4	12	24	63	< 0.50	0.050	< 9.3	< 0.78	36
	Below Lone Pine Creek	MST046		< 0.0010	< 0.00010	NA	< 0.0050	0.00070	< 0.010	0.50	1.4	26	15	27	67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 5.5	1.1	1.2	22	16	< 1.4	14	25	71	< 0.50	0.37	< 9.3	1.8	26
	Above Lone Pine Creek	MST047[f]		< 0.0010	< 0.00010	NA	< 0.0050	0.0047	< 0.0040	< 0.50	0.90	28	16	34	82	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 13	1.1	1.3	21	17	< 1.4	13	29	79	< 0.50	0.16	< 9.3	1.5	38
	Below Reese Creek	MST048	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00052	< 0.0020	0.90	0.80	27	17	28	81	NS	NS	NS	NS	NS	3.7	0.15	2.7	0.70	170	< 2.6	< 0.50	1.3	25	15	< 1.4	16	28	85	< 0.50	0.10	< 9.3	< 0.78	44
Lone Pine Creek	Above Little Blackfoot River	MST053[d]		< 0.0010	< 0.00010	NA	< 0.0050	0.00075	< 0.0020	< 0.50	1.4	29	15	30	63	NS	NS	NS	NS	NS	3.4	0.12<x<0.18	8.2	0.61	230	< 4.2	0.93	1.2	22	16	< 1.4	12	28	75	< 0.50	0.30	< 9.3	1.2	35
	Above spring-fed creek	MST054		< 0.0010	< 0.00010	NA	< 0.0050	0.0012	< 0.0020	2.0	0.82	21	13	14	97	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.70<x<3.1	1.4	1.7	25	15	< 1.4	18	27	100	< 0.50	0.070	< 9.3	0.88	25
	Below Strip Mine Creek	MST055		0.0020	< 0.00010	NA	< 0.0050	0.00082	< 0.0020	1.0	2.2	35	14	41	67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 4.6	< 0.50	1.5	26	16	< 1.4	14	26	82	< 0.50	< 0.050	< 9.3	< 0.78	25
	Above Strip Mine Creek	MST056		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.0	1.7	29	21	< 1.4	20	32	130	< 0.50	0.84	< 9.3	1.1	35
	Above West Fork Lone Pine Creek	MST058[f]		< 0.0010	< 0.00010	NA	< 0.0050	0.00072	0.0080	2.0	2.1	14	20	25	82	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 42	1.3	2.5	31	25	1.4	27	36	110	< 0.50	< 0.050	< 9.3	1.6	19
East Fork Lone Pine Creek	Below Wooley Valley Mine	MST226	X	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	1.4	2.4	30	17	< 1.4	31	59	120	< 0.50	0.73	< 9.3	1.2	40
West Fork Lone Pine Creek	Above tributary to West Fork Lone Pine Creek	MST064		0.0020	< 0.00010	NA	< 0.0050	0.00065	< 0.0020	0.80	5.7	50	13	52	83	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.4<x<3.5	1.7	6.6	51	22	< 1.4	23	57	130	< 0.50	0.49	< 9.3	1.4	45
	Above Lone Pine Creek	MST057		0.0020	< 0.00020	NA	< 0.0050	0.0011	< 0.0040	**4.4**	4.5	24	15	28	93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	6.2	3.1	5.7	32	17	< 1.4	21	30	140	0.50	< 0.050	< 9.3	< 0.78	36
Tributary to West Fork Lone Pine Creek	Above West Fork Lone Pine Creek	MST276		0.0030	< 0.00010	NA	< 0.0050	0.0011	< 0.0020	2.0	4.3	86	13	**57**	42	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.9	1.5	7.7	58	20	1.8	35	48	280	< 0.50	0.70	< 9.3	1.2	38
North Fork Lone Pine Creek	Northeast and above East Fork Lone Pine Creek	MST275[f]	X	< 0.0010	< 0.00020	NA	< 0.0050	0.011	< 0.0020	< 0.60	1.4	19	33	40	45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 4.2	< 0.50	1.0	25	15	< 1.4	18	39	57	< 0.50	0.22	< 9.3	1.5	26
West Rasmussen Ridge Creek #1	Above Lone Pine Creek	MST059[d]		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	< 0.50	3.0	33	17	< 1.4	22	39	115	< 0.50	< 0.050	< 9.3	5.5	13
West Rasmussen Ridge Creek #2	Above Lone Pine Creek	MST060		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.70	5.9	1	18	< 1.4	20	35	130	< 0.50	0.65	< 9.3	5.0	36
West Rasmussen Ridge Creek #3	Above Lone Pine Creek	MST061[d]		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	2.2	13	75	24	3.0	48	61	360	0.97	0.73	< 9.3	5.1	44
Strip Mine Creek	Above Lone Pine Creek	MST062		< 0.0010	< 0.00010	NA	< 0.0050	0.00116	< 0.0020	< 0.60	1.1	16	8.6	13	43	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.70<x<1.7	< 0.50	1.2	26	14	< 1.4	12	20	71	< 0.50	< 0.050	< 9.3	1.2	13
	Below Henry Mine	MST063		0.0020	< 0.00010	NA	< 0.0050	0.0010	< 0.0020	< 0.60	1.7	24	20	31	73	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.3<x<15	4.3	4.6	47	26	2.2	44	55	220	< 0.50	0.39	< 9.3	1.2	36
Angus Creek	Above Blackfoot River	MST126[a, f]		< 0.0010	< 0.00010	NA	< 0.0050	0.00072	< 0.0020	0.75	6.3	62	21	68	83	4.1	0.23	6.8	0.27	55	9.6	0.39	0.45<x<0.52	0.50	230	8.3	< 0.50	2.4	34	13	< 1.4	23	39	110	< 0.50	0.39	< 9.3	1.6	25
	Below No Name Creek	MST127		< 0.0010	< 0.00010	NA	< 0.0050	0.00060	< 0.0040	0.60	2.4	36	25	38	110	NS	NS	NS	NS	NS	4.8	0.083<x<0.12	< 0.21	0.72	150	3.3	< 0.50	2.7	32	13	< 1.4	21	36	110	< 0.50	0.43	< 9.3	< 0.78	29
	Above No Name Creek and below Rasmussen Creek	MST132[d]		< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	< 0.0020	1.0	2.5	32	24	37	100	NS	NS	NS	NS	NS	8.8	0.25	<1.1	1.0	140	0.43<x<1.2	< 0.50	3.3	38	17	< 1.4	24	40	140	< 0.50	0.42	< 9.3	1.1	29
	Above Rasmussen Creek	MST128	X	0.0010	< 0.00010	NA	< 0.0050	< 0.00048	< 0.0020	0.90	2.1	28	23	37	90	4.8	< 0.087	< 0.22	0.43	40	4.5	0.18<x<0.20	1.5	**1.7**	79	< 6.3	< 0.50	1.4	31	16	< 1.4	23	38	93	< 0.50	0.34	< 9.3	< 0.78	31
	R-B&M-10, below Wooley Valley Mine	MST129	X	0.0010	< 0.00020	NA	< 0.0050	0.00050	< 0.0040	1.2	1.8	36	26	45	100	6.7	0.21	0.25	0.29	54	5.8	0.083<x<1.1	5.9	**1.3**	130	**13**	2.4	3.0	41	21	< 1.4	28	45	140	< 0.50	0.11	< 9.3	3.3	21
	R-B&M-12, below Upper Angus Creek Reservoir	MST130	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00097	0.0050	**14**	**11**	**120**	**74**	**120**	**300**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.2	2.3	5.5	51	22	1.6	50	54	190	< 0.50	0.73	< 9.3	< 0.78	31
West Fork Rasmussen Creek	Above Rasmussen Creek	MST274	X	0.0030	< 0.00010	0.00020	< 0.0050	0.00056	< 0.0020	2.5	2.1	30	27	39	130	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	6.0	1.0	1.0	20	13	< 1.4	22	50	78	< 0.50	0.45	< 9.3	1.3	33
Feature	*Station Name*	*Station*		*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Se*	*Cd*	*Cr*	*Cu*	*Mo*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cu*	*Mo*	*Zn*

Notes: See the notes section of Table 5-1.

Table 5-1, Enoch Valley Mine--Aquatic and Riparian Media Censored Results[p] Continued

Feature	Station Name	Station	Upstream	Surface Water[l] May 2004 Unfiltered (mg/L)	Surface Water[l] May 2004 Filtered (mg/L)					Sediment[k] May 2004 Total (mg/kg dw)						Salmonid Fish[m] (fillet) May 2004 Total (mg/kg dw)					Forage Fish[n] (whole-body) May 2004 Total (mg/kg dw)					Benthic[o] Macroinvertebrate June 2004 Total (mg/kg dw)	Riparian Soil[h] September 2004 Total (mg/kg dw)								Riparian Vegetation[i] September 2004 Total (mg/kg dw)				
Streams and Reservoir Deltas		*Analytes*		*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Se*	*Cd*	*Cr*	*Cu*	*Mo*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cu*	*Mo*	*Zn*
Rasmussen Creek	Above Angus Creek	MST131		0.0020	< 0.00010	NA	< 0.0050	0.0012	< 0.0020	< 0.60	4.1	29	22	39	77	NS	NS	NS	NS	NS	6.3	0.17	4.3	1.5	110	5.3	< 0.50	2.0	31	15	< 1.4	21	36	110	< 0.50	0.45	< 9.3	< 0.78	33
Rasmussen Creek	M-B&M-1, below Enoch Valley Mine (1997 #38)	MST133[f]		0.0040	< 0.00010	NA	< 0.0050	0.00095	< 0.0020	1.8	2.6	30	31	46	130	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 21	0.80	2.1	32	18	< 1.4	27	39	124	< 0.50	0.24	< 9.3	< 0.78	16
Rasmussen Creek	Below West Pond Creek	MST134[f]		0.0040	0.00010	NA	< 0.0050	0.0012	< 0.0040	1.1	2.4	26	23	39	110	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.3	3.7	2.8	32	16	< 1.4	25	41	137	< 0.50	0.20	< 9.3	1.2	22
Rasmussen Creek	Above West Pond Creek	MST135[f]		< 0.0010	< 0.00010	NA	< 0.0050	0.0013	< 0.0020	3.0	3.3	26	21	40	120	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 170	2.5	2.7	34	17	< 1.4	22	45	131	< 0.50	0.14	< 9.3	< 0.78	17
Rasmussen Creek	Headwaters near Enoch Valley Mine Shop Pond	MST136[f]		0.016	0.00010	0.00010	< 0.0050	0.0022	< 0.0020	0.70	3.2	26	24	40	100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 83	1.3	2.6	42	22	< 1.4	30	30	137	< 0.50	0.58	< 9.3	1.1	36
East Fork Rasmussen Creek	Above Rasmussen Creek	MST143[f]		< 0.0010	< 0.00020	NA	0.0052	0.0012	< 0.0040	< 0.60	4.0	29	22	37	96	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 170	< 0.50	3.4	40	14	< 1.4	23	48	120	< 0.50	0.16	< 9.3	< 0.78	28
East Fork Rasmussen Creek	Headwaters	MST269		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	14	26	300	51	7.3	210	240	1400	1.5	1.5	< 9.3	1.2	130
West Pond Creek	Headwaters, below West Pond	MST144		0.23	0.00010	0.00020	< 0.0050	0.00058	0.0040	7.6	2.6	29	23	37	95	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	6.1	8.7	79	27	2.4	41	76	197	1.6	0.33	< 9.3	< 0.78	16
Blackfoot Reservoir Delta	At Blackfoot River	MRV011[f]		0.0020	< 0.00010	NA	< 0.0050	0.0010	< 0.0020	1.0	1.2	21	12	21	46	NS	NS	NS	NS	NS	4.1	0.27<x<0.37	3.6	0.46	210	< 42	0.50	1.1	22	5.0	< 1.4	11	21	50	< 0.50	0.080	< 9.3	< 0.78	21
Blackfoot Reservoir Delta	At Little Blackfoot River	MRV016		< 0.0010	< 0.00010	NA	< 0.0050	0.00094	0.0040	0.80	0.74	14	6.4	8.9	74	NS	NS	NS	NS	NS	2.8	0.080<x<0.10	2.6	0.49	160	2.7	1.6	1.1	20	6.0	< 1.4	13	< 20	87	< 0.50	< 0.050	< 9.3	< 0.78	49
Springs, Seeps, and Ponds		*Analytes*		*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Se*	*Cd*	*Cr*	*Cu*	*Mo*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cu*	*Mo*	*Zn*
Preliminary Risk-Based Benchmark				*0.0050*	*0.00060[g]*	*0.074*	*0.052[g]*	*0.020*	*0.12[g]*	*4.0*	*5.0*	*110*	*49*	*35*	*120*	*8.8*					*7.9*					*3.0*	*115*	*230*	*2300*	*920*	*115*	*2300*	*1150*	*11500*	*5.0*	*10*	*40*	*5.0*	*500*
preliminary Functional Upper Bound of Background[j], $P_{0.999,\ 0.050}$				*0.0020*	*0.00026*	*0.021*	*0.0047*	*0.0065*	*0.015*	*1.6*	*10*	*34*	*69*	*59*	*130*	*4.8*	*0.42*				*11*	*4.3*	*120*	*1.1*	*250*	*11*	*2.0*	*6.1*	*62*	*21*	*1.5*	*45*	*60*	*230*	*0.95*	*1.7*	*5.0*	*3.8*	*80*
Springs	Enoch Valley Mine, Hedin Spring	MSG001		< 0.0010	< 0.00010	0.00020	< 0.0050	< 0.00048	< 0.0040	0.60	0.64	23	21	35	71	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	0.70	0.65	19	13	0.72	19	37	66	< 0.50	0.23	< 9.3	4.6	24
Seeps	Enoch Valley Mine, West Dump Seep	MDS025		0.016	0.00050	0.00020	0.19	0.0011	0.049	100	34	730	180	240	800	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	50	35	770	1300	14	1800	230	6700	14	0.63	< 9.3	20	30
Seeps	Enoch Valley Mine, South Dump Seep	MDS026		0.43	0.0017	0.00040	0.014	0.0034	0.016	550	110	330	220	130	430	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	6.5	16	310	72	3.7	52	120	180	0.60	0.39	< 9.3	< 0.78	10
Ponds	Enoch Valley Mine, South Pond	MSP017[b]		0.52	0.00030	NA	0.015	0.0025	0.012	34	12	130	83	64	450	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	50	21	170	34	4.0	84	140	420	11	0.52	< 9.3	2.8	27
Ponds	Enoch Valley Mine, Keyhole Pond	MSP018		0.43	0.074	NA	1.9	0.086	7.2	150	1300	76	2600	320	26000	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	70	100	240	52	16	780	220	4500	17	5.1	< 9.3	4.0	330
Ponds	Enoch Valley Mine, Bat Cave Pond	MSP019		0.049	0.00010	NA	0.018	0.018	0.0060	< 0.60	1.2	21	22	33	69	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	9.8	41	270	41	4.0	91	270	890	6.4	0.38	< 9.3	0.85	48
Ponds	Enoch Valley Mine, West Pond	MSP020		0.090	0.0020	NA	0.032	0.017	0.032	12	23	170	160	93	950	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	18	24	200	29	2.6	120	130	700	15	2.4	< 9.3	< 0.78	180
Ponds	Enoch Valley Mine, Stock Pond	MSP021[c]		0.18	0.0098	NA	0.12	0.036	0.40	23	25	190	130	130	880	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	42	46	420	59	5.3	120	300	830	11	0.98	< 9.3	1.2	65
Ponds	Enoch Valley Mine, Tipple Pond	MSP022		0.041	0.00010	NA	< 0.0050	0.0093	< 0.0020	25	33	290	150	440	1200	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	6.7	7.1	67	19	2.7	35	98	211	2.8	1.4	< 9.3	1.8	43
Ponds	Enoch Valley Mine, Haul Road Pond	MSP023		0.041	0.00020	NA	0.0058	0.056	0.0060	25	23	340	120	400	730	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	25	30	360	51	10	120	440	910	3.4	2.7	< 9.3	3.8	48
Ponds	Enoch Valley Mine, Shop Pond	MSP031		< 0.0010	< 0.0001	NA	< 0.0050	0.0041	< 0.0020	< 0.60	4.8	26	21	57	100	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	24	13	350	59	3.7	120	180	890	3.6	3.1	< 9.3	17	73
Program Background		*Analytes*		*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cr*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Ni*	*V*	*Zn*	*Se*	*Se*	*Cd*	*Cr*	*Cu*	*Mo*	*Ni*	*V*	*Zn*	*Se*	*Cd*	*Cu*	*Mo*	*Zn*
Blackfoot Reservoir Delta	At Meadow Creek	MRV017	X	< 0.0010	< 0.00010	NA	< 0.0050	0.0023	< 0.0040	< 0.50	0.39	14	9.1	16	26	NS	NS	NS	NS	NS	3.0	0.072<x<0.096	1.8	0.81	160	NS	< 0.50	0.53	14	5.3	< 1.4	< 8.4	< 20	24	< 0.50	0.080	< 9.3	< 0.78	38
Meadow Creek	Above Blackfoot Reservoir	MST235	X	< 0.0010	< 0.00020	NA	< 0.0050	0.0022	< 0.0040	< 0.50	0.22	< 13	< 6.3	11	18	NS	NS	NS	NS	NS	2.7	0.065<x<0.088	3.8	0.57	130	< 12	< 0.50	0.60	22	11	< 1.4	10	23	42	< 0.50	0.11	< 9.3	< 0.78	12
Little Blackfoot River	Above Reese Creek	MST049	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00065	< 0.0020	< 0.50	1.2	26	16	29	76	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		< 0.50	1.4	25	15	< 1.4	16	29	77	< 0.50	0.14	< 9.3	2.6	28
Little Blackfoot River	Upstream of Henry cutoff road	MST254[a]	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00055	< 0.0027	< 0.50	0.78	20	13	23	75	NS	NS	NS	NS	NS	< 2.4	< 0.24	24	0.95	180	< 1.3	< 0.50	1.2	21	12	< 1.4	13	25	60	< 0.50	0.12	< 9.3	0.91	23
North Fork Wooley Valley Creek	Above Ballard Mine	MST093[f]	X	< 0.0010	< 0.00020	< 0.00020	< 0.0050	0.0062	< 0.0040	< 0.50	1.8	28	20	38	93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 8.3	0.50	2.7	23	21	< 1.4	15	30	110	< 0.50	0.35	< 9.3	1.6	27
Caldwell Creek	Below Phosphoria Formation outcrop	MST101[f]	X	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	< 0.0020	0.70	1.8	22	21	26	90	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 2.9	0.50	1.8	26	19	< 1.4	21	33	99	0.80	0.60	< 9.3	2.4	64
Stewart Creek	Above Diamond Creek	MST236[f]	X	< 0.0010	< 0.00010	0.00030	< 0.00020	< 0.00048	0.014	< 0.60	3.1	32	24	37	120	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 4.2	0.70	4.4	43	19	1.7	27	52	160	< 0.50	0.90	< 9.3	0.94	52
Timber Creek	Above Diamond Creek	MST237	X	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	0.014	< 0.60	0.90	20	18	26	66	NS	NS	NS	NS	NS	3.3	0.060<x<0.11	< 0.19	0.67	78	< 4.0	0.70	1.4	27	16	< 1.4	18	35	91	< 0.50	0.34	< 9.3	< 0.78	28

Notes:

[a] Average of the QA replicate samples reported for May 2004 sediment, surface water results.

[b] Average of the QA replicate samples reported for May 2004 surface water results only.

[c] Average of the QA replicate samples reported for May 2004 sediment results only.

[d] Average of the QA replicate samples reported for September 2004 riparian soil and riparian vegetation results only.

[e] Average of the QA replicate samples reported for September 2004 riparian soil results only.

[f] All benthic macroinvertebrate sampler results at each station were mathematically averaged except those stations footnoted (f) were composited prior to laboratory analysis.

[g] Hardness-water quality criterion calculated on an assumed 100 mg/L $CaCO_3$ hardness. Highlighted stations are those stations that exceed their station-specific criterion based on station-specific hardness.

[h] Preliminary risk-based benchmarks for riparian soil are derived from MTL's published in NRC (2005). Each MTL was multiplied by 23, which represents a 95th percentile estimate of the fraction of a dry-weight diet for pastured dairy cattle that is incidentally ingested soil. Soil ingestion rate information from Fries et al. (1982).

[i] Preliminary risk-based benchmarks for riparian vegetation are MTL's published in NRC (2005).

[j] preliminary FUBOBs calculated from all available background data for each media since 1997.

[k] The sources of the preliminary risk-based benchmarks for sediment are as follows. For selenium, value represents the toxicity threshold as recommended by Van Derveer and Canton (1997), San Joaquin Valley drainage Program (1990) and Lemly and Smith (1987) as cited in Skorupa, J., 1998, "Selenium," in P. L. Martin and D. E. Larsen (editors), Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. National Irrigation Water Quality Program Information Report No.3, Department of the Interior, pp. 139-184. For cadmium, chromium, and nickel, MacDonald, D. D., C. G. Ingersoll, and T. Berger, 2000, "Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems," Archives of Environmental Contamination and Toxicology, vol. 39, pp. 20 to 31, Probable Effects Concentration. For vanadium, lowest effect level recommended by Thompson et. al. (2005). For zinc, threshold effects doncentration recommended by MacDonald et. al. (2000).

[l] The sources of the preliminary risk-based benchmarks for surface water are the IDEQ's chronic coldwater biota standards (i.e., the USEPA's chronic water quality criterion, 40 CFR 131.36) for all analytes except vanadium. Vanadium, Oak Ridge National Laboratory, July 1996, "Preliminary Remediation Goals for Ecological Endpoints," United States Department of Energy, Office of Environmental Management.

[m] No preliminary risk-based benchmarks for salmonid fish were identified except for selenium. For selenium, the proposed USEPA fish tissue quality criterion of 8.8 mg/kg dw (fillet) was utilized.

[n] No preliminary risk-based benchmarks for forage fish were identified except for selenium. For selenium, the proposed USEPA fish tissue quality criterion of 7.9 mg/kg dw (whole-body) was utilized.

[o] The source of the preliminary risk-based benchmark for selenium in benthic macroinvertebrates is 3.0 mg/kg dw for food chain organisms as provided in Lemly, D.A., 2002, "Selenium Assessment in Aquatic Ecosystems, A guide for Hazard Evaluation and Water Quality Criteria", Springer-Verlag, New York.

[p] The 2004 results were compared to the higher of either the preliminary risk-based benchmark or the FUBOB (background), as indicated. Shading indicates an exceedance of the threshold AND that the P4 Production mine has a reasonable potential to contribute to that exceedance. Those exceedances bolded, but not shaded, are those stations that the P4 Production mine could not be reasonably expected to contribute

[q] Stations that cannot be impacted by the P_4 Production mine. Any specific analyte exceedance is bolded instead of shaded.

[r] The first FUBOB refers to Blackfoot River drainage and the second FUBOB refers to the Little Blackfoot River drainage. Significant differences were found between drainages, so separate FUBOB's were calculated. At Ballard Mine, Long Valley Creek were the only stations compared to the Little Blackfoot River figure. At Enoch Valley Mine the following stations were compared to the Little Blackfoot River figure: all Little Blackfoot River stations, all Lone Pine Creek stations, all West Rasmussen Ridge Creek

NA - Not analyzed.

NE - Not electrofished, station was not electro-fished (i.e., not applicable for electro-fishing).

NS - Not sampled. For Fish investigations, the station was electro-fished, but no sample was obtained.

Table 5-2, Henry Mine--Aquatic and Riparian Media Censored Results[p]

Feature	Station Name	Station	Upstream[q]	*Surface Water*[l]						*Sediment*[k]						*Salmonid Fish*[m] *(fillet)*					*Forage Fish*[n] *(whole-body)*					*Benthic*[o] *Macroinvertebrate*	*Riparian Soil*[h]								*Riparian Vegetation*[i]				
				May 2004						May 2004						May 2004					May 2004					June 2004	September 2004								September 2004				
				Unfiltered (mg/L)	Filtered (mg/L)					Total (mg/kg dw)						Total (mg/kg dw)					Total (mg/kg dw)					Total (mg/kg dw)	Total (mg/kg dw)								Total (mg/kg dw)				
Streams and Reservoir Deltas		*Analytes*		***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***
Preliminary Risk-Based Benchmark				*0.0050*	*0.00060*[g]	*0.074*	*0.052*[g]	*0.020*	*0.12*[g]	*4.0*	*5.0*	*110*	*49*	*35*	*120*	*8.8*					*7.9*					*3.0*	*115*	*230*	*2300*	*920*	*115*	*2300*	*1150*	*11500*	*5.0*	*10*	*40*	*5.0*	*500*
preliminary Functional Upper Bound of Background[j]*, $P_{0.999, 0.050}$*				*0.0020*	*0.00026*	*0.021*	*0.0047*	*0.0065*	*0.015*	*1.6*	*10*	*34*	*69*	*59*	*130*	*4.8*	*0.42*				*11*	*4.3*	*120*	*1.1*	*250*	*11*	*2.0*	*6.1*	*62*	*21*	*1.5*	*45*	*60*	*230*	*0.95*	*1.7*	*5.0*	*3.8*	*80*
Little Blackfoot River	Above Blackfoot Reservoir	MST234[a]		< 0.0010	< 0.00020	NA	< 0.0050	0.00080	0.0040	1.5	0.94	24	15	17	93	NS	NS	NS	NS	NS	3.9	< 0.11	3.3	0.43	200	1.2<x<1.8	< 0.50	1.0	26	8.2	< 1.4	23	< 20	170	< 0.50	0.15	< 9.3	3.3	29
	Below Long Valley Creek	MST043[a]		< 0.0010	< 0.00010	NA	< 0.0050	0.0012	0.0040	1.7	0.90	25	14	22	88	NS	NS	NS	NS	NS	6.1	0.083<x<0.10	3.8	0.41	180	1.1<x<3.2	1.1	0.83	25	8.5	< 1.4	20	27	91	< 0.50	< 0.050	< 9.3	1.6	11
	Immediately below Henry Mine (1997 #24)	MST044[f]		< 0.0010	< 0.00010	NA	< 0.0050	0.0013	< 0.0020	1.1	1.4	36	11	29	68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 8.3	5.3	2.8	46	20	< 1.4	28	38	130	**7.9**	0.26	< 9.3	4.5	31
	Above Henry Creek (1997 #23)	MST045		< 0.0010	< 0.00010	NA	< 0.0050	0.0026	0.011	1.1	0.66	25	12	21	49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 6.3	1.5	0.92	28	11	< 1.4	12	24	63	< 0.50	0.050	< 9.3	< 0.78	36
	Below Lone Pine Creek	MST046		< 0.0010	< 0.00010	NA	< 0.0050	0.00070	< 0.010	0.50	1.4	26	15	27	67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 5.3	1.1	1.2	22	16	< 1.4	14	25	71	< 0.50	0.37	< 9.3	1.8	26
	Above Lone Pine Creek	MST047[f]		< 0.0010	< 0.00010	NA	< 0.0050	0.0047	< 0.0040	< 0.50	0.90	28	16	34	82	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 13	1.1	1.3	21	17	< 1.4	13	29	79	< 0.50	0.16	< 9.3	1.5	38
	Below Reese Creek	MST048	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00052	< 0.0020	0.90	0.80	27	17	28	81	NS	NS	NS	NS	NS	3.7	0.15	2.7	0.70	170	< 2.6	< 0.50	1.3	25	15	< 1.4	16	28	85	< 0.50	0.10	< 9.3	< 0.78	44
Lone Pine Creek	Above Little Blackfoot River	MST053[d]		< 0.0010	< 0.00010	NA	< 0.0050	0.00075	< 0.0020	< 0.50	1.4	29	15	30	63	NS	NS	NS	NS	NS	3.4	0.12<x<0.18	8.2	0.61	230	< 4.2	0.93	1.2	22	16	< 1.4	12	28	75	< 0.50	0.30	< 9.3	1.2	35
	Above spring-fed creek	MST054		< 0.0010	< 0.00010	NA	< 0.0050	0.0012	< 0.0020	2.0	0.82	21	13	14	97	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.70<x<3.1	1.4	1.7	25	15	< 1.4	18	27	100	< 0.50	0.070	< 9.3	0.88	25
	Below Strip Mine Creek	MST055		0.0020	< 0.00010	NA	< 0.0050	0.00082	< 0.0020	1.0	2.2	35	14	41	67	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 4.6	< 0.50	1.5	26	16	< 1.4	14	26	82	< 0.50	< 0.050	< 9.3	< 0.78	25
	Above Strip Mine Creek	MST056		Dry	Dry	NA	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.0	1.7	29	21	< 1.4	20	32	130	< 0.50	0.84	< 9.3	1.1	35
	Above West Fork Lone Pine Creek	MST058[f]		< 0.0010	< 0.00010	< 0.00010	< 0.0050	0.00072	0.0080	2.0	2.1	14	20	25	82	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 42	1.3	2.5	31	25	1.4	27	36	110	< 0.50	< 0.050	< 9.3	1.6	19
East Fork Lone Pine Creek	Below Wooley Valley Mine	MST226	X	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	1.4	2.4	30	17	< 1.4	31	59	120	< 0.50	0.73	< 9.3	1.2	40
West Fork Lone Pine Creek	Above tributary to West Fork Lone Pine Creek	MST064		0.0020	< 0.00010	< 0.00010	< 0.0050	0.00065	< 0.0020	0.80	5.7	50	13	52	83	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.4<x<3.5	1.7	6.6	51	22	< 1.4	23	57	130	< 0.50	0.49	< 9.3	1.4	45
	Above Lone Pine Creek	MST057		0.0020	< 0.00020	NA	< 0.0050	0.0011	< 0.0040	4.4	4.5	24	15	28	93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	6.2	3.1	5.7	32	17	< 1.4	21	30	140	0.50	< 0.050	< 9.3	< 0.78	36
Tributary to West Fork Lone Pine Creek	Above West Fork Lone Pine Creek	MST276		0.0030	< 0.00010	0.00020	< 0.0050	0.0011	< 0.0020	2.0	4.3	86	13	57	42	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.9	1.5	7.7	58	20	1.8	35	48	280	< 0.50	0.70	< 9.3	1.2	38
North Fork Lone Pine Creek	Northeast and above East Fork Lone Pine Creek	MST275[f]	X	< 0.0010	< 0.00020	0.00050	< 0.0050	0.0110	< 0.0040	< 0.60	1.4	19	33	40	45	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 4.2	< 0.50	1.0	25	15	< 1.4	18	39	57	< 0.50	0.22	< 9.3	1.5	26
West Rasmussen Ridge Creek #1	Above Lone Pine Creek	MST059[d]	X	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	< 0.50	3.0	33	17	< 1.4	22	39	115	< 0.50	< 0.050	< 9.3	5.5	13
West Rasmussen Ridge Creek #2	Above Lone Pine Creek	MST060	X	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	0.70	5.9	29	18	< 1.4	20	35	130	< 0.50	0.65	< 9.3	5.0	36
West Rasmussen Ridge Creek #3	Above Lone Pine Creek	MST061[d]	X	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	2.2	13	75	24	3.0	48	61	360	0.97	0.73	< 9.3	5.1	44
Strip Mine Creek	Above Lone Pine Creek	MST062		<0.0010	< 0.00010	NA	< 0.0050	0.0011	< 0.0020	< 0.60	1.1	16	8.6	13	43	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.70<x<1.7	< 0.50	1.2	26	14	< 1.4	12	20	71	< 0.50	< 0.050	< 9.3	1.2	13
	Below Henry Mine	MST063		0.0020	< 0.00010	NA	< 0.0050	0.0010	< 0.0020	< 0.60	1.7	24	20	31	73	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.3<x<15	4.3	4.6	47	26	2.2	44	55	220	< 0.50	0.39	< 9.3	1.2	36
Long Valley Creek	Downstream of station MST050	MST270	X	Dry	Dry	NA	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.6	3.2	42	27	< 1.4	31	51	200	< 0.50	0.40	< 9.3	1.4	22
	Above Little Blackfoot River and Below East Fork Long Valley Creek	MST271		Dry	Dry	NA	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	< 0.50	1.8	34	21	< 1.4	20	43	110	< 0.50	< 0.050	< 9.3	< 0.78	12
	Below Ballard Mine, (ponded area)	MST050	X	< 0.0010	< 0.00010	NA	< 0.0050	0.017	< 0.0020	2.1	3.9	38	26	43	**140**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.9<x<5.0	< 0.50	1.3	19	9.7	< 1.4	19	32	60	< 0.50	1.3	< 9.3	2.5	31
	Spring Fed Tributary Above Long Valley Creek	MST277[a, f]		< 0.0010	< 0.00050	NA	< 0.0050	< 0.00030	< 0.010	0.80	3.7	35	23	45	150	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 29	0.70	3.4	40	29	< 1.4	25	57	140	< 0.50	0.18	< 9.3	1.3	22
East Fork Long Valley Creek	Below Henry Mine	MST051[d]		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.8	3.8	41	20	< 1.4	29	53	180	< 0.50	0.50	< 9.3	3.5	30
Henry Creek	Above Little Blackfoot River	MST052		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	3.4	6.6	75	27	2.9	47	80	250	< 0.50	0.82	< 9.3	19	48
Blackfoot Reservoir Delta	At Little Blackfoot River	MRV016		0.00061	< 0.00010	NA	< 0.0050	0.00094	0.0040	0.80	0.74	14	6.4	8.9	74	NS	NS	NS	NS	NS	2.8	0.080<x<0.10	2.6	0.49	160	2.7	1.6	1.1	20	6.0	< 1.4	13	< 20	87	< 0.50	< 0.050	< 9.3	< 0.78	49
Feature	***Station Name***	***Station***		***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***

Notes:

See the notes section of Table 5-1.

Table 5-2, Henry Mine--Aquatic and Riparian Media Censored Results[p] Continued

Feature	Station Name	Station	Upstream[q]	Surface Water[l]						Sediment[k]						Salmonid Fish[m] (fillet)				
				May 2004						May 2004						May 2004				
				Unfiltered (mg/L)	Filtered (mg/L)					Total (mg/kg dw)						Total (mg/kg dw)				
Springs, Seeps, and Ponds			*Analytes*	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***
Preliminary Risk-Based Benchmark				*0.0050*	*0.00060[g]*	*0.074*	*0.052[g]*	*0.020*	*0.12[g]*	*4.0*	*5.0*	*110*	*49*	*35*	*120*	*8.8*				
preliminary Functional Upper Bound of Background[j], $P_{0.999,\,0.050}$				*0.0020*	*0.00026*	*0.021*	*0.0047*	*0.0065*	*0.015*	*1.6*	*10*	*34*	*69*	*59*	*130*	*4.8*	*0.42*			
Springs	Henry Mine, Taylor Spring	MSG002		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	NE	NE	NE	NE	NE
Seeps	Henry Mine, South Pit Overburden Dump Seep (1997 #28)	MDS016		< 0.0010	< 0.00020	< 0.00020	0.013	< 0.00048	0.0080	9.7	13	140	120	100	370	NE	NE	NE	NE	NE
Seeps	Henry Mine, South Pit Overburden Dump Limestone Drain (FD002, 1997 #29)	MDS022[f]		< 0.0010	< 0.00010	NA	0.0057	< 0.00048	< 0.0020	1.9	1.8	< 13	34	13	76	NS	NS	NS	NS	NS
Ponds	Henry Mine, Henry Pond	MSP014		0.035	0.00020	NA	0.011	0.0028	0.0040	19	21	220	100	180	620	NE	NE	NE	NE	NE
Ponds	Henry Mine, Smith Pond	MSP015		0.15	< 0.00010	NA	< 0.0050	0.0026	< 0.0040	22	11	53	86	66	600	NE	NE	NE	NE	NE
Ponds	Henry Mine, Center Henry Pond	MSP016[a]		0.12	< 0.00010	NA	< 0.0050	0.0046	<0.0020	54	41	340	100	510	980	NE	NE	NE	NE	NE
Ponds	Henry Mine, South Pit Pond	MSP055		0.97	0.030	NA	0.57	0.038	1.9	150	100	1000	1100	940	7900	NE	NE	NE	NE	NE
Program Background			*Analytes*	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***
Blackfoot Reservoir Delta	At Meadow Creek	MRV017	X	< 0.0010	< 0.00010	NA	< 0.0050	0.0023	< 0.0040	< 0.50	0.39	14	9.1	16	26	NS	NS	NS	NS	NS
Meadow Creek	Above Blackfoot Reservoir	MST235	X	< 0.0010	< 0.00020	NA	< 0.0050	0.0022	< 0.0040	< 0.50	0.22	< 13	< 6.3	11	18	NS	NS	NS	NS	NS
Little Blackfoot River	Above Reese Creek	MST049	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00065	< 0.0020	< 0.50	1.2	26	16	29	76	NS	NS	NS	NS	NS
Little Blackfoot River	Upstream of Henry cutoff road	MST254[a]	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00055	< 0.0027	< 0.50	0.78	20	13	23	75	NS	NS	NS	NS	NS
North Fork Wooley Valley Creek	Above Ballard Mine	MST093[f]	X	< 0.0010	< 0.00020	< 0.00020	< 0.0050	0.0062	< 0.0040	< 0.50	1.8	28	20	38	93	NS	NS	NS	NS	NS
Caldwell Creek	Below Phosphoria Formation outcrop	MST101[f]	X	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	< 0.0020	0.70	1.8	22	21	26	90	NS	NS	NS	NS	NS
Stewart Creek	Above Diamond Creek	MST236[f]	X	< 0.0010	< 0.00010	0.00030	< 0.0002	< 0.00048	0.014	< 0.60	3.1	32	24	37	120	NS	NS	NS	NS	NS
Timber Creek	Above Diamond Creek	MST237	X	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	0.014	< 0.60	0.90	20	18	26	66	NS	NS	NS	NS	NS

Station	Forage Fish[n] (whole-body)					Benthic[o] Macroinvertebrate	Riparian Soil[h]								Riparian Vegetation[i]				
	May 2004					June 2004	September 2004								September 2004				
	Total (mg/kg dw)					Total (mg/kg dw)	Total (mg/kg dw)								Total (mg/kg dw)				
Analytes	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***
Preliminary Risk-Based Benchmark	*7.9*					*3.0*	*115*	*230*	*2300*	*920*	*115*	*2300*	*1150*	*11500*	*5.0*	*10*	*40*	*5.0*	*500*
preliminary Functional Upper Bound of Background[j], $P_{0.999,\,0.050}$	*11*	*4.3*	*120*	*1.1*	*250*	*11*	*2.0*	*6.1*	*62*	*21*	*1.5*	*45*	*60*	*230*	*0.95*	*1.7*	*5.0*	*3.8*	*80*
MSG002	NE	NE	NE	NE	NE	NS	< 0.50	0.92	30	22	0.56	28	43	73	< 0.50	< 0.050	< 9.3	1.9	26
MDS016	NE	NE	NE	NE	NE	NS	7.8	16	310	46	7.5	150	150	550	0.70	0.88	< 9.3	2.2	42
MDS022[f]	NS	NS	NS	NS	NS	< 130	6.9	3.0	25	14	< 1.4	63	48	140	< 0.50	0.41	< 9.3	4.0	52
MSP014	NE	NE	NE	NE	NE	NS	12	5.8	48	23	3.3	43	65	230	3.3	0.48	< 9.3	2.3	48
MSP015	NE	NE	NE	NE	NE	NS	24	5.7	46	22	1.4	48	66	270	25	0.17	< 9.3	< 0.78	120
MSP016[a]	NE	NE	NE	NE	NE	NS	45	21	160	27	5.9	87	220	560	6.5	2.3	< 9.3	< 0.78	35
MSP055	NE	NE	NE	NE	NE	NS	28	67	470	56	15	250	770	1600	65	2.9	< 9.3	5.5	340
Analytes	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***
MRV017	3.0	0.072<x<0.096	1.8	0.81	160	NS	< 0.50	0.53	14	5.3	< 1.4	< 8.4	< 20	24	< 0.50	0.080	< 9.3	< 0.78	38
MST235	2.7	0.065<x<0.088	3.8	0.57	130	< 12	< 0.50	0.60	22	11	< 1.4	10	23	42	< 0.50	0.11	< 9.3	< 0.78	12
MST049	NS	NS	NS	NS	NS	2.9<x<3.8	< 0.50	1.4	25	15	< 1.4	16	29	77	< 0.50	0.14	< 9.3	2.6	28
MST254[a]	< 2.4	< 0.24	24	0.95	180	< 1.3	< 0.50	1.2	21	12	< 1.4	13	25	60	< 0.50	0.12	< 9.3	0.91	23
MST093[f]	NS	NS	NS	NS	NS	< 8.3	0.50	2.7	23	21	< 1.4	15	30	110	< 0.50	0.35	< 9.3	1.6	27
MST101[f]	NS	NS	NS	NS	NS	< 2.9	0.50	1.8	26	19	< 1.4	21	33	99	0.80	0.60	< 9.3	2.4	64
MST236[f]	NS	NS	NS	NS	NS	< 4.2	0.70	4.4	43	19	1.7	27	52	160	< 0.50	0.90	< 9.3	0.94	52
MST237	3.3	0.060<x<0.11	< 0.19	0.67	78	< 4.0	0.70	1.4	27	16	< 1.4	18	35	91	< 0.50	0.34	< 9.3	< 0.78	28

Notes:

See the notes section of Table 5-1.

Table 5-3, Ballard Mine--Aquatic and Riparian Media Censored Results[p]																																							
Feature	*Station Name*	*Station*	*Upstream*[q]	*Surface Water*[l]						*Sediment*[k]						*Salmonid Fish*[m] *(fillet)*					*Forage Fish*[n] *(whole-body)*					*Benthic*[o] *Macroinvertebrate*	*Riparian Soil*[h]								*Riparian Vegetation*[i]				
				May 2004						**May 2004**						**May 2004**					**May 2004**					**June 2004**	**September 2004**								**September 2004**				
				Unfiltered (mg/L)	**Filtered (mg/L)**					**Total (mg/kg dw)**						**Total (mg/kg dw)**					**Total (mg/kg dw)**					**Total (mg/kg dw)**	**Total (mg/kg dw)**								**Total (mg/kg dw)**				
Streams and Reservoir Deltas		*Analytes*		***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***
Preliminary Risk-Based Benchmark				*0.0050*	*0.00060*[g]	*0.074*	*0.052*[g]	*0.020*	*0.12*[g]	*4.0*	*5.0*	*110*	*49*	*35*	*120*	*8.8*					*7.9*					*3.0*	*115*	*230*	*2300*	*920*	*115*	*2300*	*1150*	*11500*	*5.0*	*10*	*40*	*5.0*	*500*
preliminary Functional Upper Bound of Background[j], $P_{0.999, 0.050}$				*0.0020*	*0.00026*	*0.021*	*0.0047*	*0.0065*	*0.015*	*1.6*	*10*	*34*	*69*	*59*	*130*	*4.8*	*0.42*				*11*	*4.3*	*120*	*1.1*	*250*	*11*	*2.0*	*6.1*	*62*	*21*	*1.5*	*45*	*60*	*230*	*0.95*	*1.7*	*5.0*	*3.8*	*80*
Blackfoot River	Above Blackfoot Reservoir	MST232[d]		0.0020	< 0.00010	NA	< 0.0050	0.0011	< 0.0020	1.2	1.1	16	10	16	40	NS	NS	NS	NS	NS	9.5	0.043<x<0.097	4.0	0.54	120	10<x<14	< 0.50	2.0	30	8.4	< 1.4	15	31	71	< 0.50	0.055	< 9.3	2.1	9.3
	Below Woodall Mountain Creek	MST231[a]		0.0020	< 0.00020	NA	< 0.0050	0.0010	< 0.0040	< 0.50	0.69	< 13	6.7	9.7	24	NS	NS	NS	NS	NS	9.5	0.087<x<0.11	3.5	0.49	140	**27**	< 0.50	1.1	19	7.5	< 0.30	13	22	61	< 0.50	< 0.050	< 9.3	1.3	38
	Below Ballard Creek	MST019		0.0030	< 0.00020	NA	< 0.0050	0.00090	< 0.0040	0.70	1.2	20	7.7	17	31	NS	NS	NS	NS	NS	8.9	0.11	2.7	**1.3**	120	7.1	1.5	3.7	31	14	< 1.4	15	41	120	< 0.50	0.63	< 9.3	0.88	28
	Below State Land Creek	MST020[d]		0.0020	< 0.00010	NA	< 0.0050	0.00092	< 0.0020	< 0.50	1.5	31	13	30	45	NS	NS	NS	NS	NS	11	<0.11	1.4	0.69	230	3.4<x<7.5	1.7	1.1	28	11	< 1.4	16	31	80	< 0.50	0.093	< 9.3	< 0.78	44
	Above State Land Creek	MST230[a]		0.0027	< 0.00010	NA	< 0.0050	0.00091	< 0.0020	0.83	2.9	37	9.2	27	36	NS	NS	NS	NS	NS	9.0	0.11<x<0.16	1.4	0.78	**260**	**13**	1.9	0.91	20	7.7	< 1.4	13	22	60	< 0.50	0.060	< 9.3	< 0.78	28
	Below Trail Creek	MST021[a]		0.0023	< 0.00010	NA	< 0.0050	0.00093	< 0.0027	< 0.50	1.5	29	8.1	20	30	NS	NS	NS	NS	NS	9.5	0.14	1.6	**1.3**	150	10	1.2	1.6	32	14	< 0.30	22	33	100	< 0.50	< 0.050	< 9.3	< 0.78	19
	Below Wooley Valley Creek	MST022[d]		0.0030	< 0.00010	NA	< 0.0050	0.00087	< 0.0020	0.50	1.4	25	7.3	19	26	NS	NS	NS	NS	NS	**12**	0.12<x<0.16	1.5	0.80	180	4.2	0.93	1.9	25	9.3	< 1.4	13	26	63	< 0.50	0.29	< 9.3	< 0.78	25
	Below Dry Valley Creek, (1997 #20)	MST023	X	< 0.0010	< 0.00010	NA	< 0.0050	0.0018	0.0060	1.0	1.8	30	6.8	22	26	6.0	< 0.050	0.20	1.1	80	11	0.19<x<0.22	0.63	0.75	190	9.6	1.1	0.77	15	5.1	< 1.4	11	< 20	48	< 0.50	0.16	< 9.3	2.1	23
	Above Dry Valley Creek, (1997 #19)	MST024	X	0.0030	< 0.00010	NA	< 0.0050	0.00077	< 0.0020	0.80	1.5	25	8.7	23	34	NS	NS	NS	NS	NS	**14**	< 0.083	2.2	**2.1**	90	9.8	0.90	0.72	15	5.3	< 1.4	9.0	< 20	40	< 0.50	0.27	< 9.3	2.7	37
	Below Wooley Range Ridge Creek	MST025[e]	X	0.0020	< 0.00010	NA	< 0.0050	0.00086	< 0.0020	1.5	0.55	< 13	6.4	13	30	NS	NS	NS	NS	NS	11	0.17	1.4	1.1	160	5.2<x<7.9	0.93	1.0	17	7.0	< 1.4	11	< 20	51	< 0.50	0.40	< 9.3	1.4	32
	Above Wooley Range Ridge Creek	MST026	X	**0.0070**	< 0.00010	NA	< 0.0050	0.00087	< 0.0020	2.3	0.56	13	7.6	14	33	NS	NS	NS	NS	NS	1.4<x<1.8	0.080<x<0.12	4.3	0.64	90	1.9<x<6.1	0.80	2.4	28	8.8	< 1.4	15	27	83	< 0.50	0.23	< 9.3	2.1	21
	Below Angus Creek	MST027	X	**0.0080**	< 0.00020	NA	< 0.00040	0.00070	< 0.0040	1.3	0.58	14	7.8	15	32	6.1	<0.043	0.39	0.30	87	9.2	0.16	2.2	0.59	120	**12**	< 0.50	0.87	18	8.9	< 1.4	12	21	55	< 0.50	0.23	< 9.3	2.0	16
	Above Diamond Creek Rd.	MST028	X	0.0050	< 0.00020	NA	< 0.00040	0.00070	< 0.0040	0.90	0.50	13	7.9	14	30	NS	NS	NS	NS	NS	6.6	0.064<x<0.11	1.5	0.46	170	9.3	< 0.50	0.56	< 14	5.2	< 1.4	9.5	< 20	33	< 0.50	0.070	< 9.3	< 0.78	11
	Below Spring Creek	MST229	X	0.0050	< 0.00020	NA	< 0.00040	0.00070	< 0.0040	2.7	0.56	15	8.2	16	34	NS	NS	NS	NS	NS	**15**	0.028<x<0.10	2.2	0.57	160	**15**	1.0	1.3	22	10	< 1.4	26	26	120	< 0.50	0.060	< 9.3	< 0.78	16
	Above Spring Creek	MST029	X	< 0.0010	< 0.00020	NA	< 0.00040	0.00080	< 0.0040	< 0.50	0.37	15	7.4	16	24	NS	NS	NS	NS	NS	**12**	0.070<x<0.13	2.2	0.53	220	1.2	< 0.50	0.90	17	7.9	< 1.4	< 8.4	< 20	41	< 0.50	0.13	< 9.3	0.88	12
Long Valley Creek	Downstream of station MST050	MST270		Dry	Dry	NA	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	1.6	3.2	42	27	< 1.4	31	51	200	< 0.50	0.40	< 9.3	1.4	22
	Above Little Blackfoot River and Below East Fork Long Valley Creek	MST271		Dry	Dry	NA	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	< 0.50	1.8	34	21	< 1.4	20	43	110	< 0.50	< 0.050	< 9.3	< 0.78	12
	Below Ballard Mine, (ponded area)	MST050		< 0.0010	< 0.00010	NA	< 0.0050	0.017	< 0.0020	2.1	3.9	38	26	43	**140**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.9<x<5.0	< 0.50	1.3	19	9.7	< 1.4	19	32	60	< 0.50	1.3	< 9.3	2.5	31
	Spring Fed Tributary Above Long Valley Creek	MST277[a, f]		< 0.0010	< 0.00050	NA	< 0.0050	< 0.00030	< 0.010	0.80	3.7	35	23	45	**150**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 29	0.70	3.4	40	29	< 1.4	25	57	140	< 0.50	0.18	< 9.3	1.3	22
Ballard Creek	Above Blackfoot River	MST066[f]		0.0010	< 0.00020	0.00040	< 0.0050	0.0044	0.012	3.2	2.3	24	15	44	75	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 170	9.8	2.9	25	24	< 1.4	20	62	94	< 0.50	0.37	< 9.3	1.3	26
	Headwaters	MST067		0.029	0.0013	0.00060	0.013	0.0084	0.027	82	34	200	160	270	890	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	39	24	160	40	9.0	100	210	660	0.60	0.26	< 9.3	< 0.78	14
West Fork Ballard Creek	Headwaters	MST068		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	25	35	260	39	12	110	350	690	40	0.090	< 9.3	2.3	29
Short Creek	Below Ballard Mine	MST069		0.60	0.00010	0.00070	0.025	0.0011	< 0.015	420	11	31	84	27	310	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	310	2.8	4.2	39	21	1.7	23	45	130	3.1	0.34	< 9.3	< 0.78	13
Wooley Valley Creek	Above Blackfoot River	MST088		Dry	Dry	NA	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	< 0.50	2.6	33	16	< 1.4	21	43	130	< 0.50	0.56	< 9.3	1.4	36
	Above Loadout Creek at road	MST272		< 0.0010	< 0.00020	NA	< 0.0050	0.011	< 0.0040	2.0	4.1	42	28	**65**	**150**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 11	2.5	5.6	61	23	< 1.4	34	93	200	< 0.50	0.38	< 9.3	2.4	16
	Above ponding and below MST089	MST273[f]		< 0.0010	< 0.00050	NA	< 0.0050	0.0046	< 0.010	1.7	2.8	31	19	37	100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 170	6.9	3.6	34	20	< 1.4	21	43	130	< 0.50	0.18	< 9.3	0.78	37
	Below North Fork Wooley Valley Creek	MST089[f]		0.0010	< 0.00020	0.00040	< 0.0050	0.0017	< 0.0040	15	5.5	42	28	48	170	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 21	6.6	4.7	39	22	< 1.4	24	46	160	< 0.50	0.36	< 9.3	1.2	38
	Above North Fork Wooley Valley Creek	MST090[f]		0.0010	< 0.00050	NA	< 0.0050	0.0029	< 0.010	0.60	0.93	22	10	27	58	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 1300	< 0.50	1.7	21	16	< 1.4	11	23	78	< 0.50	0.24	< 9.3	1.2	26
North Fork Wooley Valley Creek	Above Wooley Valley Creek	MST092[d, f]		0.0060	< 0.00050	NA	0.0090	0.0022	< 0.010	57	9.3	99	50	94	320	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 8.3	19	6.0	70	25	< 1.4	36	74	250	< 0.50	0.53	< 9.3	2.3	50
Spring-fed tributary #1 of North Fork Wooley Valley Creek	Below Ballard Mine	MST094[f]		0.023	< 0.00020	NA	< 0.0050	0.0017	< 0.0040	8.2	1.3	40	24	43	100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	17	0.70	1.4	37	20	< 1.4	24	44	92	< 0.50	0.12	< 9.3	1.2	17
Spring-fed tributary #2 of North Fork Wooley Valley Creek	Below Ballard Mine	MST095		0.059	0.00020	NA	0.0068	0.0023	0.013	22	11	95	58	86	250	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	15	16	170	42	6.1	70	210	440	13	1.2	< 9.3	2.3	36
Tributary of North Fork Wooley Valley Creek	Below Ballard Mine	MST096		0.020	< 0.00010	0.00020	< 0.0050	0.00072	0.017	17	0.55	29	14	25	80	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	Dry	1.3	0.44	17	10	< 1.4	17	31	43	2.4	0.22	< 9.3	< 0.78	22
Blackfoot Reservoir Delta	At Blackfoot River	MRV011[f]		0.0020	< 0.00010	NA	< 0.0050	0.0010	< 0.0020	1.0	1.2	21	12	21	46	NS	NS	NS	NS	NS	4.1	0.27<x<0.37	3.6	0.46	210	< 42	0.50	1.1	22	5.0	< 1.4	11	21	50	< 0.50	0.080	< 9.3	< 0.78	21
Feature	***Station Name***	***Station***		***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***

Notes:

See the notes section of Table 5-1.

Table 5-3, Ballard Mine--Aquatic and Riparian Media Censored Results[p] Continued

Feature	Station Name	Station	Upstream[q]	Surface Water[l] May 2004						Sediment[k] May 2004 Total (mg/kg dw)						Salmonid Fish[m] (fillet) May 2004 Total (mg/kg dw)					Forage Fish[n] (whole-body) May 2004 Total (mg/kg dw)					Benthic[o] Macroinvertebrate June 2004 Total (mg/kg dw)	Riparian Soil[h] September 2004 Total (mg/kg dw)								Riparian Vegetation[i] September 2004 Total (mg/kg dw)				
				Unfiltered (mg/L)	Filtered (mg/L)																																		
Springs, Seeps, and Ponds		*Analytes*		***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***
Preliminary Risk-Based Benchmark				*0.0050*	*0.00060[g]*	*0.074*	*0.052[g]*	*0.020*	*0.12[g]*	*4.0*	*5.0*	*110*	*49*	*35*	*120*	*8.8*					*7.9*					*3.0*	*115*	*230*	*2300*	*920*	*115*	*2300*	*1150*	*11500*	*5.0*	*10*	*40*	*5.0*	*500*
preliminary Functional Upper Bound of Background[j], $P_{0.999,\ 0.050}$				*0.0020*	*0.00026*	*0.021*	*0.0047*	*0.0065*	*0.015*	*1.6*	*10*	*34*	*69*	*59*	*130*	*4.8*	*0.42*				*11*	*4.3*	*120*	*1.1*	*250*	*11*	*2.0*	*6.1*	*62*	*21*	*1.5*	*45*	*60*	*230*	*0.95*	*1.7*	*5.0*	*3.8*	*80*
Springs	Ballard Mine, Garden Hose Spring	MSG003		0.47	< 0.00010	0.00090	< 0.0050	0.0011	0.00084	180	11	140	73	97	330	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	52	10	200	31	3.5	75	87	320	9.3	0.87	< 9.3	0.94	15
	Ballard Mine, Holmgren Spring	MSG004		0.016	< 0.00010	0.00060	< 0.0050	0.0016	0.0030	29	9.1	490	310	56	340	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	6.3	11	130	38	4.3	71	85	300	1.3	0.23	< 9.3	3.9	24
	Ballard Mine, Cattle Spring	MSG005[d]		0.0070	< 0.00010	0.00050	< 0.0020	< 0.00048	0.0030	8.8	1.5	29	26	33	92	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	17	1.3	19	15	< 1.4	15	30	69	0.93	0.26	< 9.3	< 0.78	32
	Ballard Mine, Southeast Spring	MSG006		0.22	< 0.00010	0.00080	< 0.0020	0.00073	0.00075	290	1.3	37	17	34	73	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	89	570	1.4	16	7.0	1.2	11	24	47	17	0.19	< 9.3	0.87	19
Seeps	Ballard Mine, Pit #2 Upper Dump Seep	MDS030		0.52	< 0.00010	0.0015	< 0.0050	0.00090	0.0030	250	3.3	38	25	39	89	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	10	7.0	98	40	3.4	53	93	250	2.0	0.18	< 9.3	< 0.78	15
	Ballard Mine, Pit #2 Lower Dump Seep South	MDS031		0.38	< 0.00010	0.0010	< 0.0050	0.00099	0.0018	83	8.3	110	97	37	350	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	3.5	3.2	63	25	2.3	55	69	180	12	0.76	< 9.3	1.4	34
	Ballard Mine, Pit #2 Lower Dump Seep North	MDS032		0.50	< 0.00010	0.00050	0.0067	0.0011	0.0040	1300	8.3	75	78	45	260	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	160	7.0	78	30	4.0	68	66	280	11	0.20	< 9.3	< 0.78	29
	Ballard Mine, Goat Seep	MDS033		1.5	0.00020	0.00070	0.011	0.0016	0.0070	470	6.3	130	99	62	300	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	24	53	300	270	47	770	120	2600	6.7	0.52	< 9.3	1.3	36
Ponds	Ballard Mine, Dredge Pond	MSP010		0.63	0.00080	NA	0.025	0.016	0.0090	110	26	590	250	200	940	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	53	23	2800	73	31	1600	210	1000	27	2.8	< 9.3	4.8	58
	Ballard Mine, Upper Elk Pond	MSP011[a]		0.048	0.0010	NA	0.0099	0.013	0.011	34	67	620	100	470	720	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	48	110	790	130	49	190	570	1200	8.5	2.0	< 9.3	3.1	55
	Ballard Mine, Lower Elk Pond	MSP012		0.12	0.0015	NA	0.0081	0.027	0.010	63	140	730	190	540	1500	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	38	130	910	130	42	160	770	1200	10	4.4	< 9.3	6.1	130
	Ballard Mine, Northeast Pond	MSP013		Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	24	30	374	70	14	140	230	660	23	0.92	< 9.3	3.5	19
	Ballard Mine, Pit #4 Stock Pond	MSP059		0.029	0.00040	NA	0.0072	0.012	0.0070	49	43	670	340	660	1800	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	39	28	460	110	25	230	300	990	16	2.8	< 9.3	46	92
	Ballard Mine, Pit #6 Pond	MSP062		0.0020	0.0021	NA	0.015	0.0062	0.020	58	120	740	380	920	2400	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NS	21	130	1000	120	43	260	650	1400	3.2	11	< 9.3	12	79
Program Background		*Analytes*		***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cr***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Ni***	***V***	***Zn***	***Se***	***Se***	***Cd***	***Cr***	***Cu***	***Mo***	***Ni***	***V***	***Zn***	***Se***	***Cd***	***Cu***	***Mo***	***Zn***
Blackfoot Reservoir Delta	At Meadow Creek	MRV017	X	< 0.0010	< 0.00010	NA	< 0.0050	0.0023	< 0.0040	< 0.50	0.39	14	9.1	16	26	NS	NS	NS	NS	NS	3.0	0.072<x<0.096	1.8	0.81	160	NS	< 0.50	0.53	14	5.3	< 1.4	< 8.4	< 20	24	< 0.50	0.080	< 9.3	< 0.78	38
Meadow Creek	Above Blackfoot Reservoir	MST235	X	< 0.0010	< 0.00020	NA	< 0.0050	0.0022	< 0.0040	< 0.50	0.22	< 13	< 6.3	11	18	NS	NS	NS	NS	NS	2.7	0.065<x<0.088	3.8	0.57	130	< 12	< 0.50	0.60	22	11	< 1.4	10	23	42	< 0.50	0.11	< 9.3	< 0.78	12
Little Blackfoot River	Above Reese Creek	MST049	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00065	< 0.0020	< 0.50	1.2	26	16	29	76	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.9<x<3.8	< 0.50	1.4	25	15	< 1.4	16	29	77	< 0.50	0.14	< 9.3	2.6	28
	Upstream of Henry cutoff road	MST254[a]	X	< 0.0010	< 0.00010	NA	< 0.0050	0.00055	< 0.0027	< 0.50	0.78	20	13	23	75	NS	NS	NS	NS	NS	< 2.4	< 0.24	24	0.95	180	< 1.3	< 0.50	1.2	21	12	< 1.4	13	25	60	< 0.50	0.12	< 9.3	0.91	23
North Fork Wooley Valley Creek	Above Ballard Mine	MST093[f]	X	< 0.0010	< 0.00020	< 0.00020	< 0.0050	0.0062	< 0.0040	< 0.50	1.8	28	20	38	93	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 8.3	0.50	2.7	23	21	< 1.4	15	30	110	< 0.50	0.35	< 9.3	1.6	27
Caldwell Creek	Below Phosphoria Formation outcrop	MST101[f]	X	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	< 0.0020	0.70	1.8	22	21	26	90	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 2.9	0.50	1.8	26	19	< 1.4	21	33	99	0.80	0.60	< 9.3	2.4	64
Stewart Creek	Above Diamond Creek	MST236[f]	X	< 0.0010	< 0.00010	0.00030	< 0.0002	< 0.00048	0.014	< 0.60	3.1	32	24	37	120	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	< 4.2	0.70	4.4	43	19	1.7	27	52	160	< 0.50	0.90	< 9.3	0.94	52
Timber Creek	Above Diamond Creek	MST237	X	< 0.0010	< 0.00010	NA	< 0.0050	< 0.00048	0.014	< 0.60	0.90	20	18	26	66	NS	NS	NS	NS	NS	3.3	0.060<x<0.11	< 0.19	0.67	78	< 4.0	0.70	1.4	27	16	< 1.4	18	35	91	< 0.50	0.34	< 9.3	< 0.78	28

Notes:

See the notes section of Table 5-1.

Enoch Valley Mine (EVM)

In summary, reviewing Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, for surface water, only two selenium threshold exceedances (MST136 and MST144) and no other COPC threshold exceedances at stream stations are attributable to EVM. Both of which are headwater streams. All seep, and most pond stations (except MSP031) have selenium threshold exceedances and sporadic exceedances of the other COPC thresholds at numerous stations (MDS025, MDS026, MSP017, MSP018, MSP019, MSP020, MSP021, MSP022, and MSP023). Note: exceedances of other COPC thresholds only occurred at stations that also have a selenium threshold exceedance. The sole spring, Hedin Spring (MSG001), did not have any exceedance of any of the COPC thresholds for surface water or sediment.

For sediment, only one selenium threshold exceedance (MST144) and no other COPC threshold exceedances (except one threshold exceedance for vanadium at MST126) at stream stations are attributable to EVM. Both seep stations (MDS025 and MDS026) and most pond stations (except MSP019) have exceedances of most COPC thresholds. However, exceedances of sediment thresholds is likely for spring, seep, and pond stations considering these stations usually exist on waste rock soil expected to be elevated in trace elements. Note: exceedances of other COPC thresholds usually only occurred at stations that also have a selenium threshold exceedance.

Henry Mine (HM)

In summary, reviewing Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, for surface water, no COPC threshold exceedances at stream or seep stations are attributable to HM. All pond stations (MSP014, MSP015, MSP016, and MSP055) have selenium threshold exceedances and no other COPC thresholds are exceeded, except MSP055 (where COPC thresholds were exceeded for Cd, Ni, V and Zn). Note: exceedances of other COPC thresholds only occurred at stations that also have a selenium threshold exceedance.

For sediment, only one selenium threshold exceedance (at MST057) and one zinc threshold exceedance (MST277) at stream stations are attributable to HM. One of two seep stations (MDS016) and all pond stations have exceedances of almost all COPC thresholds for sediment. However, exceedances of sediment thresholds is likely for spring, seep, and pond stations considering these stations usually exist on waste rock soil expected to be elevated in trace elements. Note: exceedances of other COPC thresholds usually only occurred at stations that also have a selenium threshold exceedance.

Ballard Mine (BM)

In summary, reviewing Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results*, for surface water, six selenium threshold exceedances (at MST067, MST069, MST092, MST094, MST095, and MST096) and one other COPC threshold exceedance (MST067 for cadmium) at stream stations were attributable to BM. Note: most stream station COPC threshold exceedances at BM are at spring-fed headwater stream stations. All spring and seep stations (MSG003, MSG004, MSG005, MSG006, MDS030, MDS031, MDS032, and MDS033) and most pond stations (MSP010, MSP011, MSP012, MSP059, and MSP062) have selenium and other COPC threshold exceedances. No other COPC thresholds are exceeded.

For sediment, seven stream stations (MST067, MST069, MST089, MST092, MST094, MST095, and MST096) have at least selenium threshold exceedances and various other COPC threshold exceedances attributable to BM. Again note: most stream station sediment COPC threshold exceedances at BM are at spring-fed headwater stream stations. All spring, seeps, and pond stations (except MSP013-dry) have at least selenium threshold exceedances and various other COPC threshold exceedances. However, exceedances of sediment thresholds is likely for spring, seep, and pond stations considering these stations usually exist on waste rock soil expected to be elevated in trace elements. Note: exceedances of other COPC thresholds only occurred at stations that also have a selenium threshold exceedance.

5.1.2.2 Spatial Wire Diagrams (SWDs)

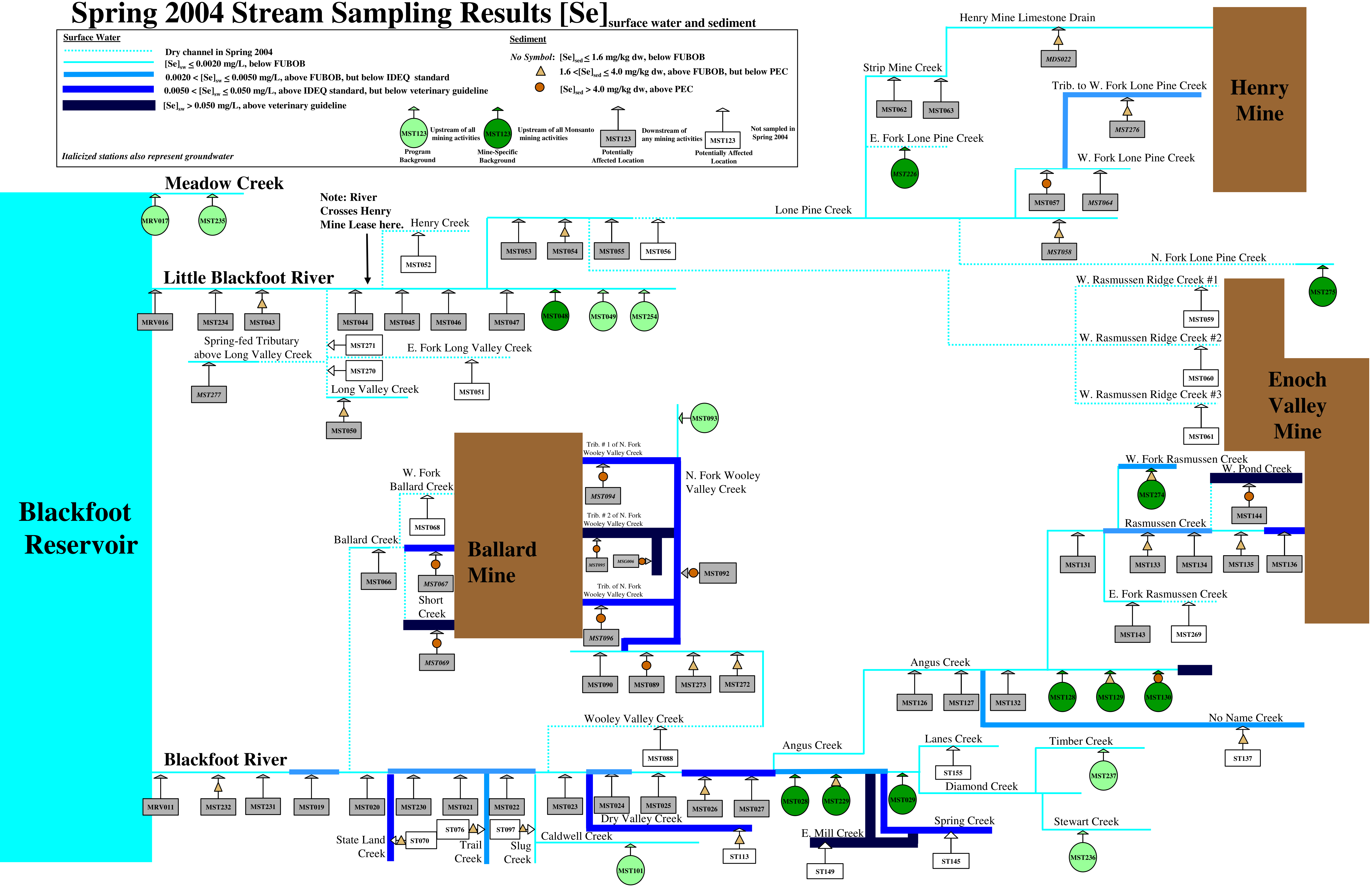
The SWDs present a visual evaluation of the aquatic and riparian SI data programmatically for all three P4 mines. The SWDs simplify and present the stream network of flowing systems for P4 mines, from each P4 mine downstream to the Blackfoot Reservoir. Refer to Figure 2-1, *Program Sampling Locations*, for a map of the stream/station network. Results from each sampling station were compared to various thresholds for each analyte of aquatic and riparian media. Each threshold (or range) is presented visually by a different (stream) line thickness and color. For display purposes, each station's result is compared to the threshold ranges and applied to the line medially (i.e., the line thickness and color for each station is depicted halfway upstream, and halfway downstream of a sampling station to the next sampling station or stream confluence, which ever is closer). Please note that concentration representations for State Land Creek, Trail Creek, Slug Creek, Dry Valley Creek, East Mill Creek, Spring Creek, Lanes Creek, and No Name Creek, come from historical IMA data that is not presented herein. This data will be reported in the comprehensive SI report.

Sampling stations are identified by either circles or rectangles on the SWD. Light green circles identify programmatic background stations (upstream of all mining activities) and dark green circles identify mine-specific background stations (stations that are upstream of all P4 mines but that could be influenced by other non-P4 mining activities). Grey rectangles identify stations that are downstream of all mining activities, and white rectangles identify stations that were not sampled. Also note, referring to the surface water SWDs, a light blue dashed line indicates a stream channel that was dry during the sampling event.

The SWDs are for visual display only and are not to scale; north is generally upwards on the SWD. The program area is drained by two main streams, the Blackfoot River, and the Little Blackfoot River, both of which flow generally west into the Blackfoot Reservoir. Both the Blackfoot River and Little Blackfoot River potentially drain Enoch Valley Mine and Ballard Mine, while Henry Mine is only potentially drained by the Little Blackfoot River.

The surface water and sediment SWDs are presented in Appendix D by COPC. Surface water and sediment results from each sampling station were compared to the threshold ranges indicated on each SWD. For discussion purposes, the selenium surface water and sediment SWD is also presented as Figure 5-1 below because selenium is the most prevalent COPC.

Spring 2004 Stream Sampling Results [Se]$_{\text{surface water and sediment}}$



Enoch Valley Mine (EVM)

Reviewing the selenium SWD for surface water at EVM, one station (MST144) exceeded the veterinary guideline of (0.050 mg/L), one station (MST136) is within the range of the State of Idaho surface water quality standard and the veterinary guideline (0.0050 to 0.050 mg/L), and two stations (MST133 and MST134) and one EVM-specific background station (MST274) are within the range of the FUBOB and the State of Idaho surface water quality standard (0.0020 to 0.0050 mg/L). No threshold exceedances are present for the other COPCs as illustrated on the respective SWDs except for nickel (MST143 and MST275) and MST275 for vanadium; both exceed FUBOB.

Reviewing the same SWD for sediment, one station (MST144) is above the probable effects concentration (PEC) (4.0 mg/kg dw), and one station (MST133) and one EVM-specific background station (MST274) is above the FUBOB but below the PEC (1.6 to 4.0 mg/kg dw). Vanadium is the only only COPC with threshold exceedances for the other COPCs as illustrated on the respective SWDs.

In summary, although several exceedances of COPC thresholds for surface water and sediment are observed in close proximity to EVM, elevated concentrations are not being transported downstream (via Angus Creek) to the Blackfoot River or transported downstream (via Lone Pine Creek) to the Little Blackfoot River. Angus Creek has no exceedances before or even after the confluence of No Name Creek (which has an elevated station on it), therefore it appears that Angus Creek is not contributing to exceedances in the Blackfoot River. Furthermore, based on available data, it appears that the elevated selenium levels are being transported into the Blackfoot River via East Mill Creek and Spring Creek, which are upstream from two mine specific background stations (MST028 and MST229). Vanadium in sediment is the only threshold that was exceeded by COPCS's for surface water or sediment. However, since no exceedances are found downstream, it appears that EVM is not contributing any vanadium above background levels. Therefore, based on current data it appears as though EVM is not contributing significant levels of COPCs to the Blackfoot or Little Blackfoot River.

Henry Mine (HM)

Reviewing the selenium SWD for surface water at HM, two stations (MST276 and MDS022) are within the range of FUBOB and the State of Idaho surface water quality standard (0.0020 to 0.0050 mg/L). All other station results are below the FUBOB for selenium. No threshold exceedances are present for the other COPCs as illustrated on the respective SWDs except DS022 for Nickel and MST050 for vanadium; both exceed FUBOB.

Reviewing the same SWD for sediment, one station (MST057) is above the PEC (4.0 mg/kg dw), and three stations (MST058, MST276, and MDS022) are above FUBOB but below the PEC (1.6 to 4.0 mg/kg dw). No threshold exceedances are present for the other sediment COPCs, except one station (MST064) for cadmium was above FUBOB but below the PEC (1.6 to 4.0 mg/kg dw) and two stations for vanadium (MST055 and MST050, above LEL but below FUBOB) as illustrated on the respective SWDs.

In summary, although a couple of exceedances of COPC thresholds for surface water and sediment are observed in close proximity to HM, elevated concentrations are not being transported downstream (via Lone Pine or Long Valley Creeks) to the Little Blackfoot River. Therefore, based on current data it appears as though HM is not contributing significant levels of COPCs to the Little Blackfoot River.

Ballard Mine (BM)

Reviewing the selenium SWD for surface water at BM, three stations (MST069, MST095, and MSG006) exceeded the veterinary guideline of (0.050 mg/L), and four stations (MST067, MST092, MST094, and MST096) are within the range of the State of Idaho surface water quality standard and the veterinary guideline (0.0050 to 0.050 mg/L). There are numerous stream stations for which COPCs exceed FUBOB. Additionally, MST067 exceeds the hardness dependent cadmium standard.

Reviewing the same SWD for selenium in sediment, eight stations (MST067, MST069, MST089, MST092, MST094, MST095, MST096, and MSG006) are above the PEC (4.0 mg/kg dw), and two stations (MST272 and MST273) are above the FUBOB but below the PEC (1.6 to 4.0 mg/kg dw). Numerous other threshold exceedances are present for all of the other COPCs as illustrated on the respective SWDs; however, these exceedances occur at stations that also exceeded a selenium threshold for sediment.

In summary, there are numerous exceedances of COPC thresholds for surface water and numerous exceedances of COPC thresholds for sediment in close proximity to BM. Most elevated streams are spring-fed tributaries or headwater streams that are intermittent. Both Ballard Creek and Wooley Valley Creek are intermittent streams, and the streams become dry before reaching the Blackfoot River for all years of the area-wide and mine-specific investigations, including May 2006 which was determined by IDEQ to be an above average water year. Therefore, based on current data it appears as though elevated COPC concentrations are not being transported significantly downstream (via Ballard Creek or Wooley Valley Creek) to the Blackfoot River or downstream (via Long Valley Creek) to the Little Blackfoot River. Therefore, based on current data it appears as though BM is not contributing significant levels of COPCs to the Blackfoot River or Little Blackfoot River.

Little Blackfoot River

Reviewing the SWDs in respect to the Little Blackfoot River, no surface water COPC thresholds were exceeded and only one selenium exceedance in sediment (MST043) is above the FUBOB but below the PEC (1.6 to 4.0 mg/kg dw). Therefore, based on current data it appears as though P4 mines are not contributing COPCs at any level above FUBOB to the Little Blackfoot River or its sediment.

Blackfoot River

Reviewing the SWDs in respect to the Blackfoot River surface water quality, two stations (MST026 and MST027) are within the range of the State of Idaho surface water quality standard and the veterinary guideline for selenium (0.0050 to 0.050 mg/L), and four stations (MST019, MST021, MST024, and MST230) (sporadically located along the Blackfoot River) and two mine specific background stations (MST028 and MST229) are within the range of the FUBOB and the State of Idaho surface water quality standard for selenium (0.0020 to 0.0050 mg/L). The two exceedances at MST026 and MST027 are upstream of any BM influence, but downstream of

EVM (Angus Creek). However, both mine-specific background stations located upstream of these two exceeded stations (MST028 and MST229) also have elevated selenium above the FUBOB, indicating contribution of selenium from upstream, non-P4 related sources. Historical data also indicate selenium contributions to the Blackfoot River are also likely from East Mill Creek and Spring Creek, in addition to additional historical contributions further downstream from Dry Valley Creek and State Land Creek. No other COPCs thresholds were exceeded along the Blackfoot River.

Reviewing the SWDs in respect to the Blackfoot River sediment quality, two stations (MST026 and MST232) (sporadically located) were above the FUBOB but below the PEC (1.6 to 4.0 mg/kg dw).

Therefore, based on current data it appears as though P4 mines are not contributing COPCs at any level above FUBOB to the Blackfoot River or its sediment.

Selenium Flux

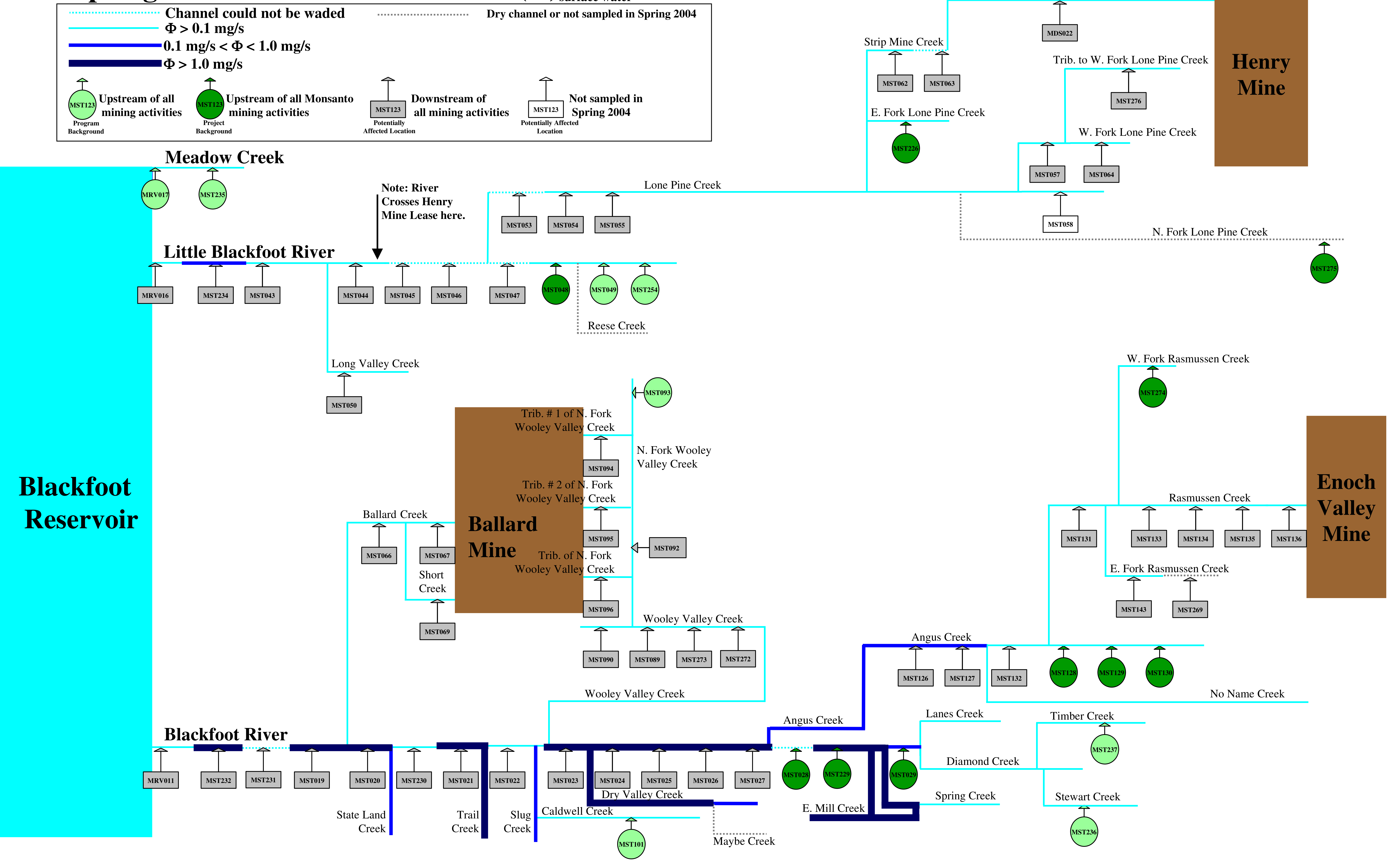
Flux is generally defined as the volumetric flow rate, or the amount that flows through a unit area per a unit of time. Stream mass flux, often referred to as load, is the mass of chemical solutes or sediment transported at a point in a stream during a period of time. Selenium flux (Φ) was calculated using the analytical laboratory results (in µg/L) and field determined flow (in feet^3/second) to produce the Φ (in mg/second).

By sampling a river under these different conditions, the amount of material that passes a station, known as the mass flux of a constituent (expressed as tons per day), can be reliably determined by multiplying the concentration of a constituent by the stream discharge.

Constituent mass fluxes can be compared among stations and across spatial scales. For example, yields of contaminants (expressed as tons per square mile) can be compared between stations; gains or losses in a river reach can be determined between any two stations; and amounts of materials delivered to a reservoir or estuary can be calculated. The ability to determine these three values-source, transport, and delivery of constituents-enables a broad range of scientific and policy issues to be addressed.

Reviewing the selenium flux SWD presented below as figure 5.2, in respect to the P4 mines and respective study area, no increased selenium flux is observed near or emanating from a P4 mine. In fact, most increased selenium flux areas ($\Phi > 1.0$ mg/s) are along the Blackfoot River (MST019, MST020, MST021, MST023, MST024, MST025, MST026, MST027, and MST232), at Blackfoot River mine specific background stations (MST229), and from additional non-P4 impacted stream inputs (based on historical data) to the Blackfoot River (such as East Mill Creek, Dry Valley Creek, and Trail Creek). MST127 (Angus Creek below the confluence of No Name Creek) shows an increase in selenium flux compared to the station upstream of the confluence, but this increase is attributable to Rasmussen Ridge Mine, and not Enoch Valley Mine. No Name Creek drains the former and not the latter. Thus, based on current data, even though some elevated selenium concentrations are observed near the P4 mines, the surface water flow at such stations contribute comparatively miniscule selenium flux (loading) to the Blackfoot River or the Little Blackfoot River.

Spring 2004 Selenium Flux Results (Φ)$_{\text{surface water}}$



5.2 TASK 2: AIR INVESTIGATION

This task will be reported in the comprehensive SI report.

5.3 TASK 3: GEOLOGY AND GROUNDWATER INVESTIGATION

This task is evaluated and reported in the Monitoring Well Installation Technical Memorandum (MWITM) draft version 4 (MWH, 2006) for the Final 2005 Phase II Supplemental SI Groundwater Work Plan (MWH, 2005b).

5.4 TASK 4: SOIL INVESTIGATION

This task included four subtasks. Three subtasks, 4b, 4c, and 4d discussed below, involved field sampling.

5.4.1 Subtask 4a— Water Balance Investigation

This subtask will be reported in the comprehensive SI report.

5.4.2 Subtask 4b—Characterization of Extent of Riparian Zone Soil Contamination at Streams, Ponds, Seeps, Springs, and Wetlands

This subsection presents an evaluation of the riparian soil data through a tabulated comparison of each mine's data to COPC thresholds, and visually with SWDs of flowing systems (i.e., no ponds are presented).

5.4.2.1 Data comparison to COPC thresholds

Refer to the first two paragraphs of Section 5.1.2.1 for instructions on how to interpret the data comparison to COPC thresholds tables.

Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, and Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results* compare the tabulated Phase I SI aquatic and riparian media results (including surface water, sediment, salmonid fish, forage fish, benthic macroinvertebrates, riparian soil, and riparian vegetation) to the COPC thresholds indicated on the respective table. The comparison is discussed by mine below.

<u>**Enoch Valley Mine (EVM)**</u>

In summary, reviewing Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, for riparian soil, no exceedances of COPC thresholds are present at stream seep, spring, or pond stations, except on copper threshold exceedance at a seep (MDS025) is attributable to EVM.

Henry Mine (HM)
In summary, reviewing Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, for riparian soil, no exceedances of COPC thresholds are present at stream seep, spring, or pond stations.

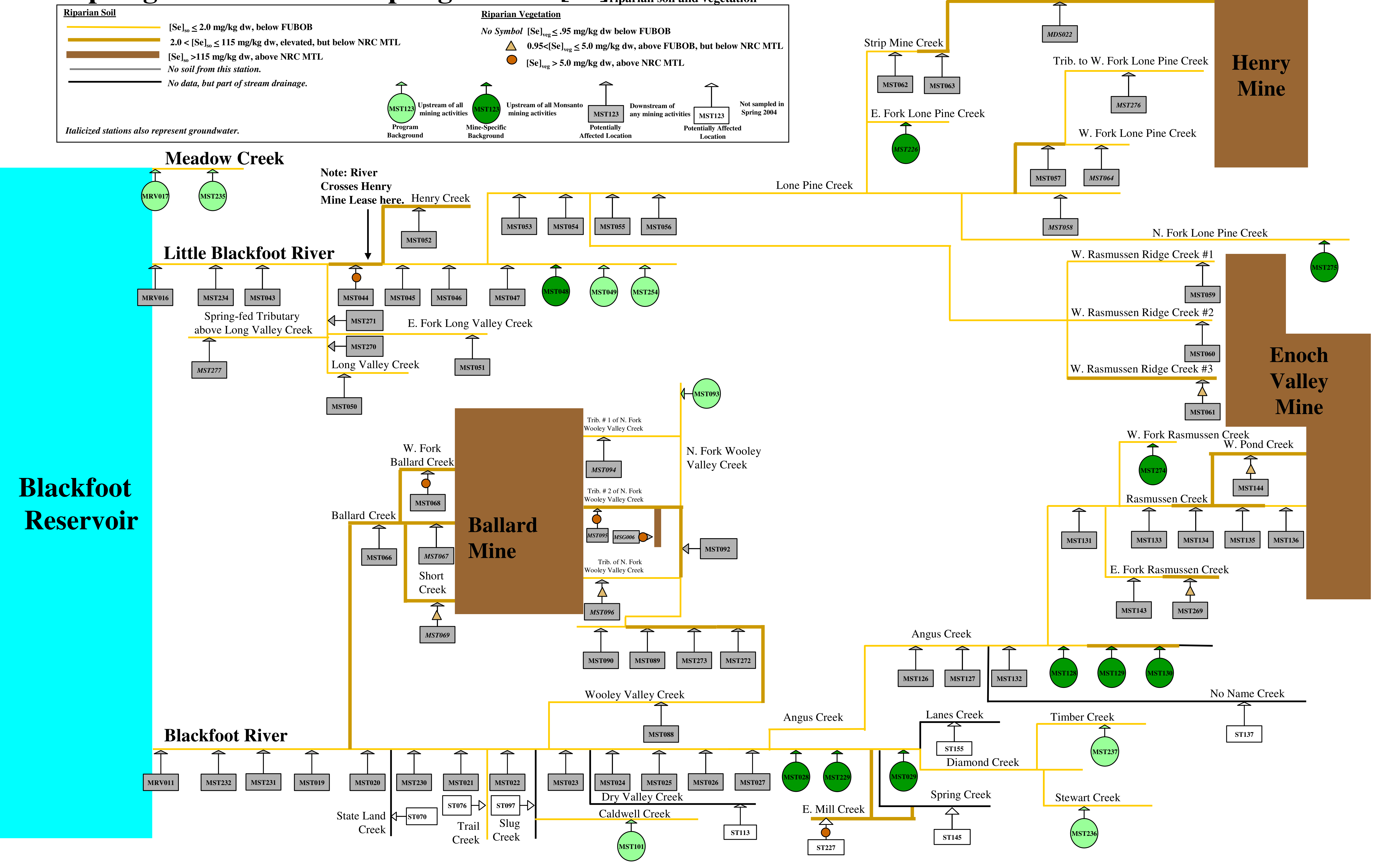
Ballard Mine (BM)
In summary, reviewing Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results*, for riparian soil, no exceedances of COPC thresholds are present at stream stations. Two selenium threshold exceedances (one seep MDS032, one spring MSG006) and one chromium exceedance (pond MSP010) are attributable to BM.

5.4.2.2 Spatial Wire Diagrams (SWDs)

Refer to the first two paragraphs of Section 5.1.2.2 for instructions on how to interpret the SWDs.

The riparian soil and vegetation SWDs are presented in Appendix G by COPC. Riparian soil results from each sampling station were compared to the threshold ranges indicated on each SWD. For discussion purposes, the selenium riparian soil SWD is also presented as Figure 5-3 below because selenium is the most prevalent COPC.

Spring 2004 Stream Sampling Results [Se]riparian soil and vegetation



Enoch Valley Mine (EVM)

Reviewing the selenium SWD for riparian soil at EVM, five stations (MST134, MST135, MST144, and MST269) are above the FUBOB (2.0 mg/kg dw) but below the NRC MTL (115 mg/kg dw). Other COPCs have threshold exceedances (above respective FUBOBs and below NRC MTLs) at several sampling stations (Cd: MST144 and MST269; Cr: MST144 and MST269; Cu: MST136, MST144 and MST269; Mo: MST144 and MST269; Ni: MST269; V: MST144 and MST269; Zn: MST269) as illustrated on the respective SWDs. No stations exceeded the respective COPC NRC MTL.

In summary, although several exceedances of COPC thresholds for riparian soil are observed in close proximity to EVM, elevated selenium concentrations are not being transported downstream (via Angus Creek) to the Blackfoot River or downstream (via Lone Pine Creek) to the Little Blackfoot River. Therefore, based on current data it appears as though EVM is not contributing significant levels of COPCs to the Blackfoot River or Little Blackfoot River.

Henry Mine (HM)

Reviewing the selenium SWD for riparian soil at HM, four stations (MST052, MST057, MST063, and MDS022) are above the FUBOB (2.0 mg/kg dw) but below the NRC MTL (115 mg/kg dw). Most other COPCs have threshold exceedances (above respective FUBOBs and below NRC MTLs) at a few sampling stations (Cd: MST064 and MST276; Cu: MST058, MST063, and MST064; Mo: MST276; Ni: MDS022; Zn: MST276) as illustrated on the respective SWDs. No stations exceeded the respective COPC NRC MTL.

In summary, although several exceedances of COPC thresholds for riparian soil are observed in close proximity to HM, elevated selenium concentrations are not being transported downstream (via Lone Pine Creek) to the Little Blackfoot River. Therefore, based on current data it appears as though HM is not contributing significant levels of COPCs to the Little Blackfoot River, except for a slightly elevated selenium result at MST052 that might be contributing to the slightly elevated selenium result at MST044 on the Little Blackfoot River.

Ballard Mine (BM)

Reviewing the selenium SWD for riparian soil at BM, one station (MSG006) was above the NRC MTL (115 mg/kg dw). Nine stations (MST066, MST067, MST068, MST069, MST089, MST092, MST095, MST272, and MST273) are above the FUBOB (2.0 mg/kg dw) but below the NRC MTL (115 mg/kg dw). Other COPCs have threshold exceedances (above respective FUBOBs and below NRC MTLs) at numerous sampling stations (Cd: MST067, MST068, and MST095; Cr: MST067, MST068, MST092, and MST095; Cu: MST066, MST067, MST068, MST089MST092, MST095, and MST272; Mo: MST067, MST068, MST069, and MST095; Ni: MST067, MST068, and MST095; V: MST066, MST067, MST068, MST092, MST095, and MST272;Zn: MST067, MST068, MST092, and MST095;) as illustrated on the respective SWDs. No other COPC NRC MTLs were exceeded.

In summary, various riparian zones along streams have elevated COPCs above the FUBOB.

Little Blackfoot River

Reviewing the selenium SWD for riparian soil along the Little Blackfoot River, one station (MST044) is above the FUBOB (2.0 mg/kg dw) but below the NRC MTL (115 mg/kg dw). No other COPC thresholds are exceeded.

Blackfoot River

Reviewing the selenium SWD for riparian soil along the Blackfoot River, no COPC thresholds are exceeded.

5.4.3 Subtask 4c—Characterization of Waste Rock Dump Extent of Soil Contamination

Note, for the purposes of this data evaluation, one-half the reporting limit (RL/2) is substituted for those COPC concentrations that are censored at the reporting limit (< RL).

A circum-dump reconnaissance of waste rock dumps at each mine was performed in June 2004 to identify and map mass wasting areas and potential mass wasting areas along dump boundaries and locate potential sampling areas for this subtask. The reconnaissance results and randomly selected sampling sites (for soil and vegetation sampling) are documented in the *Field Investigation Update July 2004 Mass Wasting Sampling Effort* technical memorandum, which is included in *Field Investigation Update July 2004 Mass Wasting Sampling Effort* (MWH, 2004g) and has been included as Appendix J.

This subtask is discussed in conjunction with *Subtask 6f—Characterization of Waste Rock Dump Extent of Vegetation Contamination* under Section 5.6.6 below because the data were evaluated together. The evaluation for both of these subtasks is only presented under this subtask.

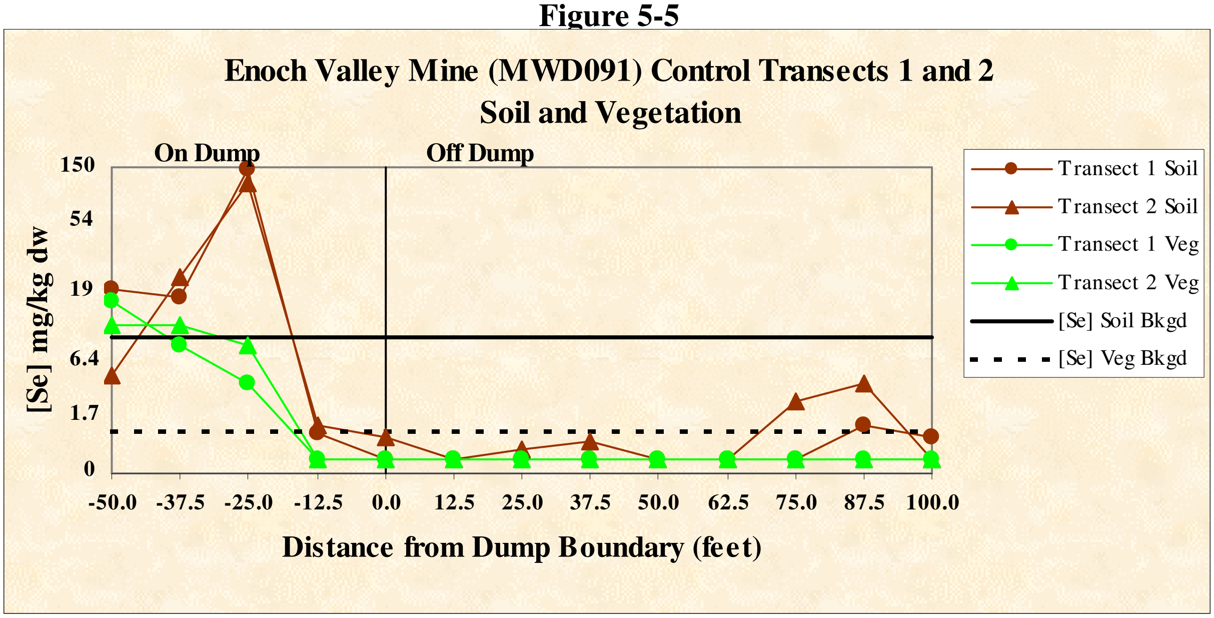
For visual illustration, a photograph of each sampling station is provided below. Under each photograph is a line-plot of the corresponding soil and co-located vegetation results (selenium, mg/kg dw) over the distance from the dump boundary in feet. The upland soil and vegetation selenium FUBOB (background) is also plotted on the graph. One-half the reporting limit (RL/2) is substituted for those selenium concentrations that are censored at the reporting limit (< RL). A brief interpretation of the plot is provided.

IDEQ has expressed concern that background levels for waste rock dump soil and vegetation appear to be at unreasonably high levels. This has been noted and is explained and discussed further in Appendix M.

Figure 5-4
Enoch Valley Mine MWD091 Transect Location (Control)

On waste rock dump, looking towards undisturbed land

Figure 5-5

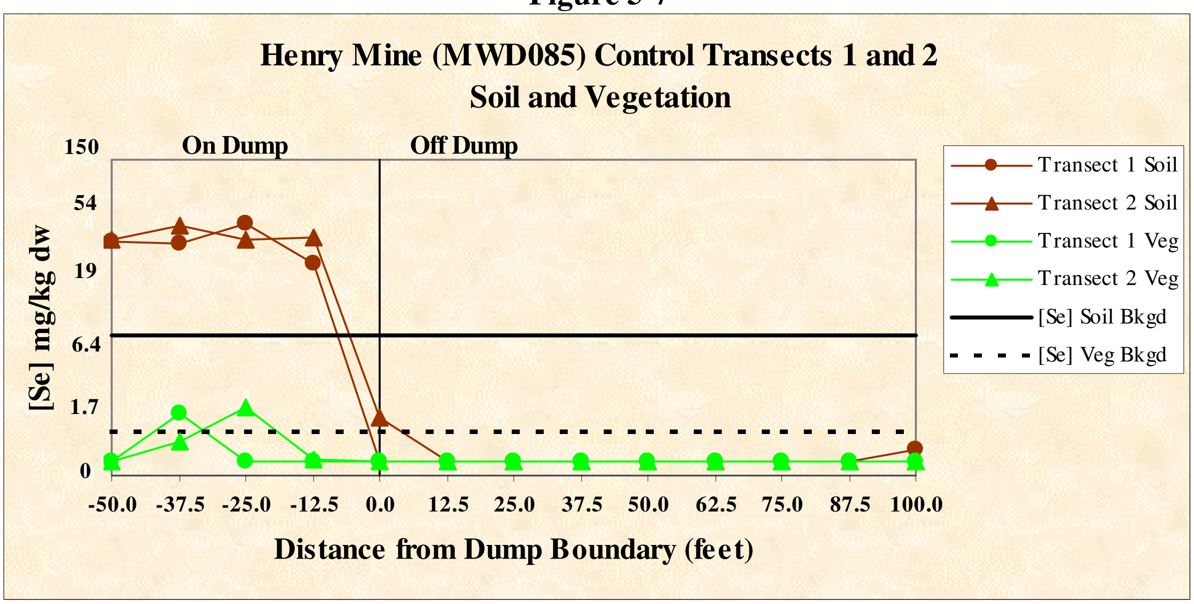


As expected for a control site, the soil and vegetation results on the dump are elevated above background (FUBOB) and drop immediately below background levels at the predicted/assumed border of the waste rock dump. The remaining sample locations off of the dump for the control sites are located on undisturbed land and sloping uphill (i.e., no chance of mass wasting/transport to occur). Undisturbed land was identified by soil observation and vegetation present (sage brush).

Figure 5-6
Henry Mine MWD085 Transect Location (Control)

Undisturbed land, looking towards waste rock dump.

Figure 5-7

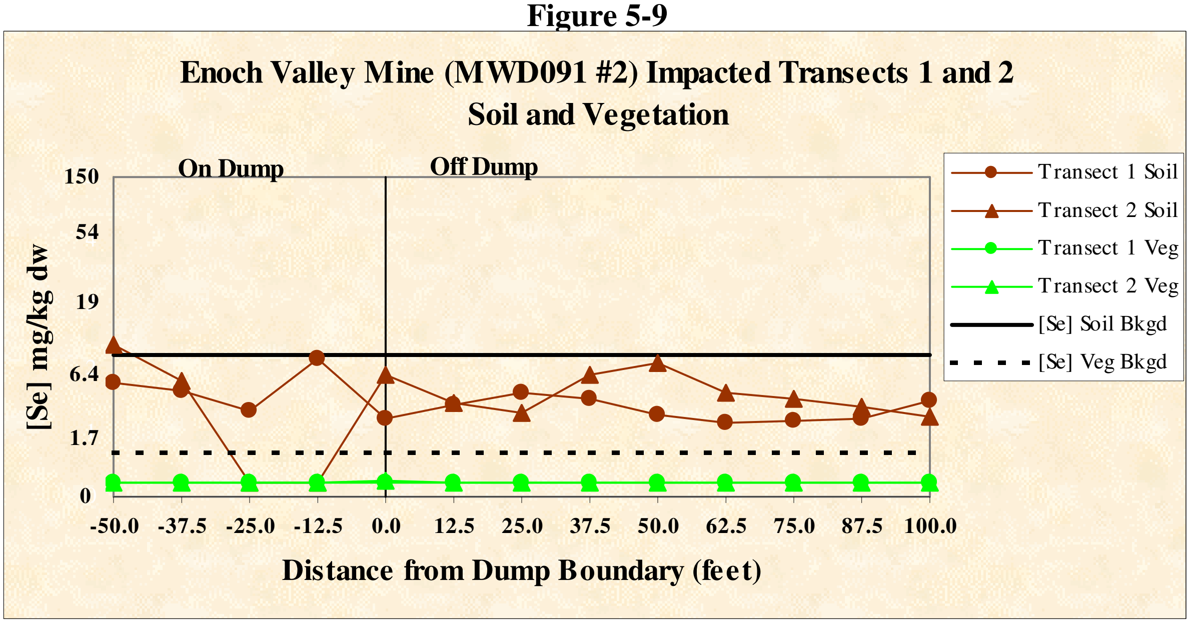


As expected for a control site, the soil and vegetation results on the dump are elevated above background (FUBOB) and drop immediately below background levels at the predicted/assumed border of the waste rock dump. The remaining sample locations off of the dump for the control sites are located on undisturbed land and sloping uphill (i.e., no chance of mass wasting/transport to occur. Undisturbed land was identified by soil observation and vegetation present (sage brush).

Figure 5-8
Enoch Valley Mine MWD091 Transect Location (Impacted)

On waste rock dump, looking towards undisturbed land.

Figure 5-9

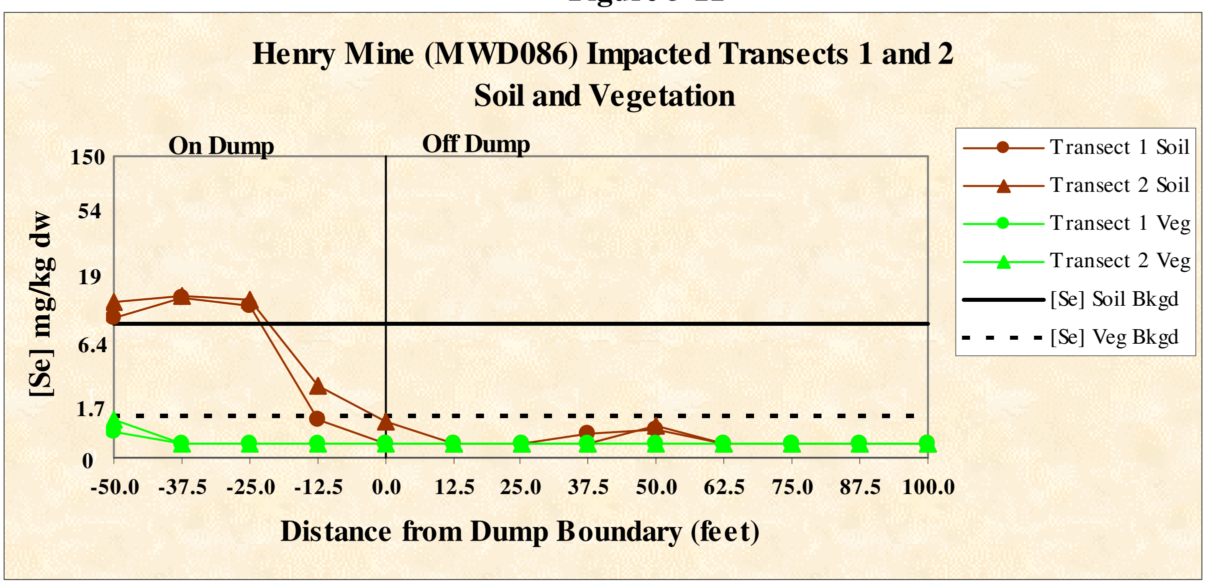


Interestingly, most of the on-dump soil concentrations and all of the vegetation concentrations are below background (FUBOB). No evidence of off-dump transport is evident.

Figure 5-10
Henry Mine MWD086 Transect Location (Impacted)

On waste rock dump, looking towards undisturbed land (past fence).

Figure 5-11

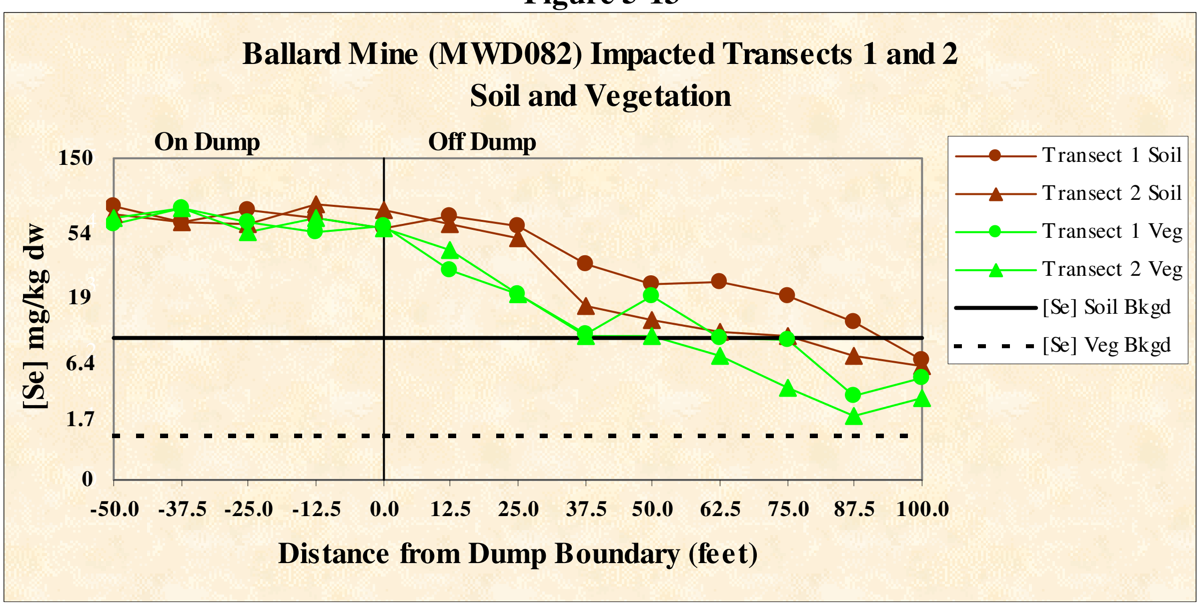


Similar to the control site, the soil results on the dump are elevated above background and drop immediately below background (FUBOB) levels at the predicted/assumed border of the waste rock dump, indicating no off-dump transport has occurred. Interestingly, all of the on-dump and off-dump vegetation concentrations are below background, also indicating no off-dump transport has occurred.

Figure 5-12
Ballard Mine MWD082 Transect Location (Impacted)

On waste rock dump, looking towards undisturbed land.

Figure 5-13



Off-dump transport is evident by the fact that the off-dump concentrations do not immediately drop below background (FUBOB) levels for soil and vegetation. Note: the on-dump percent-slope was very steep (90% slope) making off-dump transport likely. Also note, the field team visually observed shale in sampling areas off of the dump, also indicating off-dump transport. Another possibility explaining this data is that the field team did not correctly identify the dump boundary, but the presence of trees indicates that the area is undisturbed native land.

A summary of the control and impacted plots is provided below Table 5-4, *Mass Wasting Summary*.

Table 5-4 Mass Wasting Summary					
Station Name	**[Se] > FUBOB [a]**				**% Slope On-dump**
	On-dump		**Off-dump**		
	Soil	**Veg**	**Soil**	**Veg**	
Control					
Enoch Valley Mine Waste Dump	Y	Y	N	N	34
Henry Mine North Pit Overburden	Y	Y	N	N	1.7
Impacted					
Enoch Valley Mine Waste Dump	Y	N	N	N	49, 29
Henry Mine Center Pit #1 Overburden	Y	N	N	N	67
Ballard Mine Pit #3 Overburden	Y	Y	**Y**	**Y**	90

[a] Soil FUBOB = 8.1 mg/kg dw, Veg FUBOB = 1.0 mg/kg dw

The two control stations were successful in demonstrating an immediate drop in soil and vegetation concentrations to below background levels at the visually predicted dump boundary. Two potentially impacted stations confirmed no off-dump transport had occurred. The only sampling evidence of off-dump transport was observed at Ballard Mine on an area of the dump that was very steep (90% slope). In addition, visual evidence was also observed indicating that off-dump transport had occurred in this area and/or that the field team did not correctly identify the dump boundary.

Dump terminus can be determined by observing slope direction, vegetation type, and evidence of material transport. If necessary, geo-reconnaissance rather than extensive sampling to determine the actual dump boundary is recommended.

5.4.4 Subtask 4d—Agronomic Testing of Unreclaimed, Poorly Reclaimed, and Well Reclaimed Land (Ballard Mine only)

A reconnaissance of Ballard Mine, specifically waste rock dumps, was performed in June 2004 to visually identify and roughly map three types of reclaimed areas, un-reclaimed, poorly-reclaimed, and well-reclaimed areas, and locate potential sampling locations for this subtask. The reconnaissance results and randomly selected sampling sites are documented in the memorandum included in Appendix C, *Subtask 4d, Agronomic Reconnaissance and Sampling Memo*.

The sampling results of this subtask will be evaluated and reported in the Comprehensive SI Report as this task supports the EE/CA.

5.5 TASK 5: AQUATIC ECOLOGICAL INVESTIGATION

This task included two subtasks. Both Subtask 5a and 5b, discussed below, involved field sampling.

5.5.1 Subtask 5a—Stream Habitat Assessment

Note, for the purposes of this data evaluation, one-half the reporting limit (RL/2) is substituted for those COPC concentrations that are censored at the reporting limit (< RL).

The habitat assessment was conducted on all stream stations in the hope of being able to develop a predictive model differentiating stream habitat that supports fish from stream habitat that does not support fish. Multiple logistic regressions were used to develop possible models defined on three input variables:

- Logarithm of selenium concentration in surface water, $\ln[Se]_{sw}$;
- Logarithm of selenium concentration in sediment, $\ln[Se]_{sed}$; and,
- Rapid bioassessment score, RBS.

The rapid bioassessment protocol is published by USEPA (Barbour, et. al., 1999) and characterizes physical habitat quality by assessing the following ten categories:

- Frequency of riffles (or bends);
- Channel flow status;
- Embeddedness;
- Velocity and depth regime;
- Sediment deposition;
- Epifaunal substrate and available cover;
- Vegetative protection;
- Channel alteration;
- Riparian vegetative zone width; and,
- Bank stability.

Each category is assigned 0 to 10 points based upon field inspection, and the ten categories are summed to generate the RBS for the station. The maximum RBS is 200 points, with a high score indicating a high overall quality of physical habitat.

The dependent variable is the presence or absence of fish at a station. The presence of fish was determined at each station by electroshocking, and each station was electroshocked once. If fish were found, that is, of course, an unambiguous indication of the presence of fish. Unfortunately, not finding fish is not an unambiguous indication of their absence. Thus, for those stations where no fish were found, but are bounded by nearby stations where fish were found and are hydraulically connected to such nearby stations, we assumed fish to be present. The data should be considered preliminary in nature and should not preclude further sampling and study of areas identified as poor habitat.

Of the 66 stations included in the assessment, seven were thus adjusted:

- MST044;
- MST045;
- MST046;
- MST047;
- MST049;
- MST130;
- MST133; and,
- MST236.

The resulting data matrix used in the modeling is presented in Table 5-5—*In-Stream Habitat Assessment Data Matrix.*

Table 5-5: In-Stream Habitat Assesssment Data Matrix

Station	[Se]sw, mg/L	[Se]sed, mg/kg dw	RBP Habitat Score	Fish
MST019	0.0030	0.70	144	1
MST020	0.0020	0.25	112	1
MST021	0.0023	0.25	69	1
MST022	0.0030	0.50	S	1
MST023	0.00050	1.0	145	1
MST024	0.0030	0.80	101	1
MST025	0.0020	1.5	139	1
MST026	**0.0070**	2.3	129	1
MST027	**0.0080**	1.3	107	1
MST028	0.0050	0.90	94	1
MST029	0.00050	0.25	107	1
MST043	0.00050	1.7	57	1
MST044	0.00050	1.1	143	1
MST045	0.00050	1.1	31	1
MST046	0.00050	0.50	73	1
MST047	0.00050	0.25	48	1
MST048	0.00050	0.90	151	1
MST049	0.00050	0.25	139	1
MST050	0.00050	2.1	52	0
MST053	0.00050	0.25	52	1
MST054	0.00050	2.0	25	0
MST055	0.0020	1.0	43	0
MST057	0.0020	4.4	44	0
MST058	0.00050	2.0	34	0
MST062	0.00050	0.30	47	0
MST063	0.0020	0.30	29	0
MST064	0.0020	0.80	55	0
MST066	0.0010	3.2	40	0
MST067	0.029	82	44	0
MST069	0.60	420	40	0
MST089	0.0010	15	30	0
MST090	0.0010	0.60	41	0
MST092	0.0060	57	41	0
MST093	0.00050	0.25	35	0
MST094	0.023	8.2	29	0
MST095	0.059	22	50	0
MST096	0.020	17	46	0
MST101	0.00050	0.70	29	0
MST126	0.00050	0.75	139	1
MST127	0.00050	0.60	52	1
MST128	0.0010	0.90	133	1
MST129	0.0010	1.2	104	1
MST130	0.00050	**14**	87	1
MST131	0.0020	0.30	85	1
MST132	0.00050	1.0	131	1
MST133	0.0040	1.8	48	1
MST134	0.0040	1.1	25	0
MST135	0.00050	3.0	24	0
MST136	0.016	0.70	49	0
MST143	0.00050	0.30	8	0
MST144	0.23	7.6	3	0
MST229	0.0050	2.7	107	1
MST230	0.0027	0.83	116	1
MST231	0.0020	0.25	88	1
MST232	0.0020	1.2	115	1
MST234	0.00050	1.5	76	1
MST235	0.00050	0.25	127	1
MST236	0.00050	0.30	130	1
MST237	0.00050	0.30	107	1
MST254	0.00050	0.25	103	1
MST272	0.00050	2.0	30	0
MST273	0.00050	1.7	30	0
MST274	0.0030	2.5	35	0
MST275	0.00050	0.30	4	0
MST276	0.0030	2.0	56	0
MST277	0.00050	0.80	7	0

Notes:
- regional background station
- water concentration assumed to be censored
- censored result; value is one-half the reporting limit
- exceeds preliminary risk-based benchmark at a station proximal to a Monsanto mine
- no fish observed, but presumed to be present based on hydraulic connection to adjacent stations with fish present

bolded result exceeds preliminary risk-based benchmark at a station distal to a Monsanto mine

With the three input variables—$\ln[Se]_{sw}$, $\ln[Se]_{sed}$, and RBS—seven models can be developed using each variable separately, any two in combination, or all three. The multiple logistic regressions were performed so as to find the best of these seven models. If we denote the presence or absence of fish as F, the seven models, in order of declining fit, are:

Model	α	β	Overall Error Rate
$F = f(\ln[Se]_{sw}, RBS)$	0.067	0.056	0.061
$F = f(RBS)$	0.067	0.14	0.11
$F = f(\ln[Se]_{sed}, RBS)$	0.067	0.056	0.061
$F = f(\ln[Se]_{sw}, \ln[Se]_{sed}, RBS)$	0.067	0.056	0.061
$F = f(\ln[Se]_{sed})$	0.40	0.14	0.26
$F = f(\ln[Se]_{sw}, \ln[Se]_{sed})$	0.43	0.11	0.26
$F = f(\ln[Se]_{sw})$	0.63	0.25	0.42

Preferably the type I error rate (i.e., the false positive error rate, α) would be no greater than 0.050. None of the seven models attains this, but four get very close. Preferably the type II error rate (i.e., the false negative error rate, β) would be no greater than 0.20. All but one of the models attains this. The best model is a function of $\ln[Se]_{sw}$ and RBS. This model does a good job of classifying the existing data with an overall error rate (i.e., an overall misclassification rate) of only 0.061. The inputs to the model were for the Spring (May) 2004, including analytical inputs; therefore, the model should be used with Spring data. Note the data gap assessment memorandum dated October 19, 2006 identifies a potential need to confirm or refine the model. A potential refinement of the model could be to confirm it during a Fall (September) sampling event.

Of the two input variables in the best model, it appears that RBS is the more important. This is evidenced by $F = f(RBS)$ being the second best model in terms of fit, and $F = f(\ln[Se]_{sw})$ being the worst model. That physical habitat is, by far, more important in determining the presence or absence of fish at a given station is further documented graphically in the following two figures:

Figure 5-14

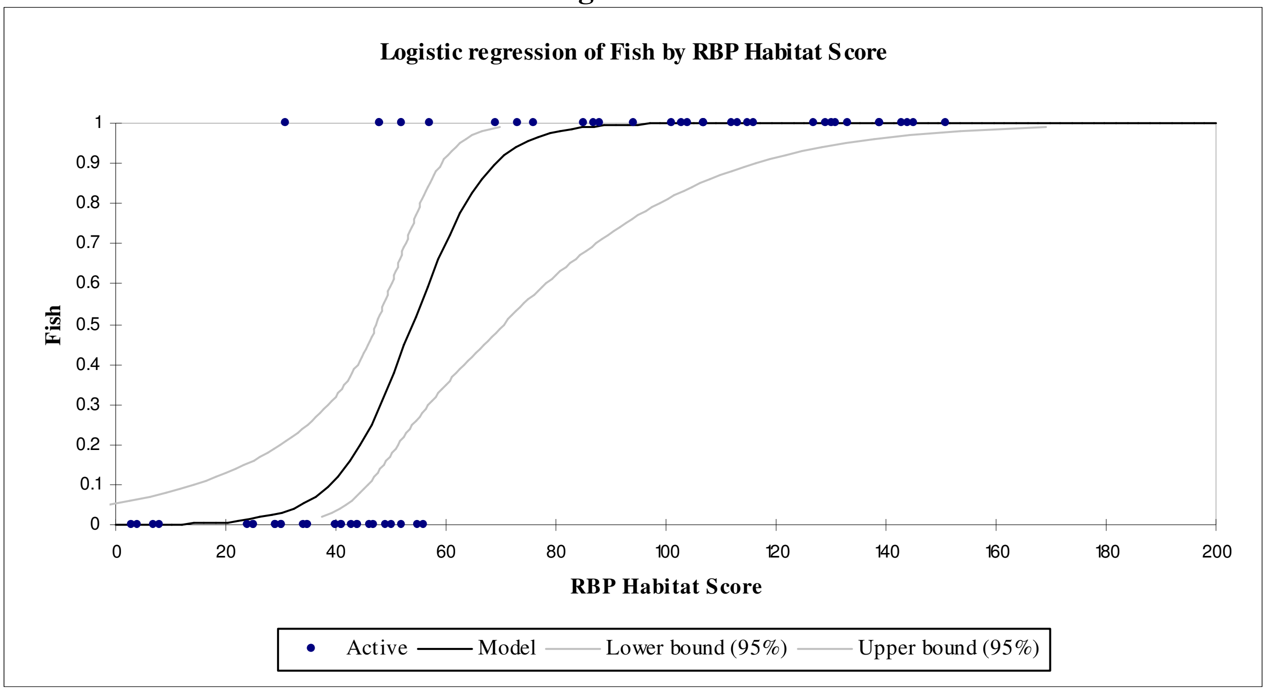
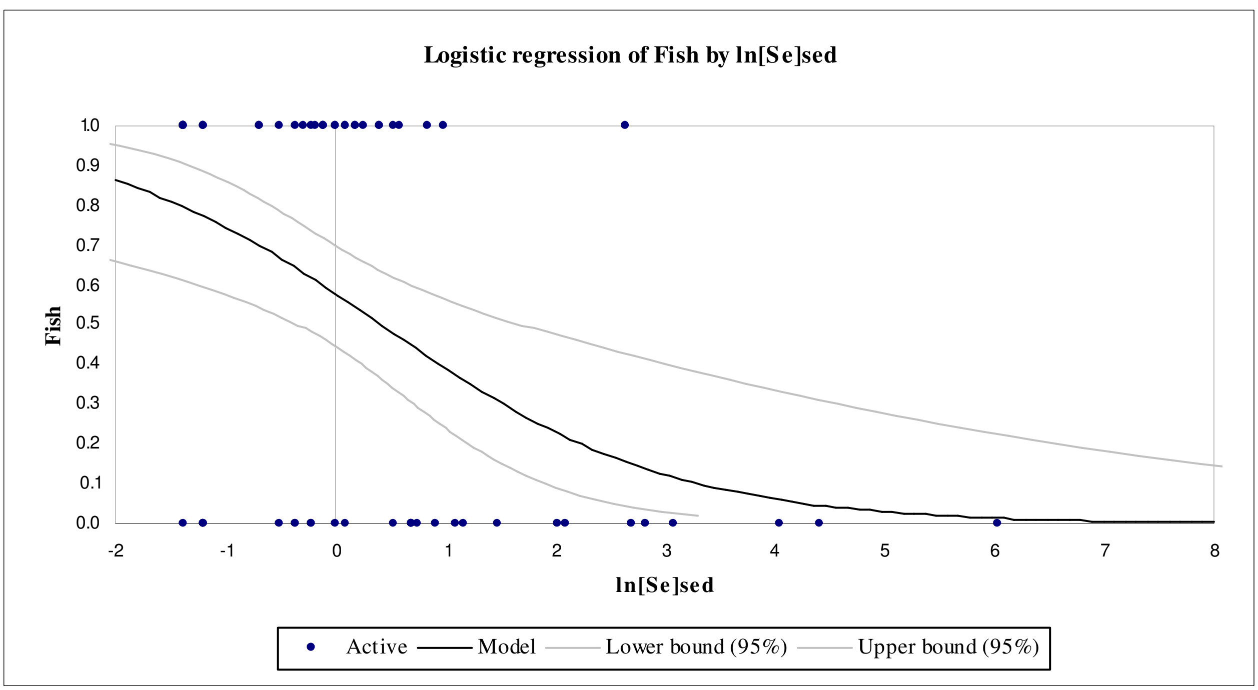


Figure 5-15



The first graph shows that RBS does a much better job of discriminating between fish-bearing and non-fish-bearing habitat than does $\ln[Se]_{sw}$. In fact, F = f(RBS) is a credible model; whereas, $F = f(\ln[Se]_{sw})$ is far from credible. However, the most credible model uses both input variables and the equation for it is:

$$F = \frac{1}{1 + e^{15.7 + 1.12\ln[Se]_{sw} - 0.15 RBS}}.$$

It is thus possible to accurately predict whether a given stream reach does or does not support fish by assessing the reach using USEPA's rapid bioassessment protocol and by taking a sample of water within the reach and analyzing it for selenium. This ability to differentiate habitats could prove useful in future site characterization efforts and in prioritizing or tailoring remedies for specific locations.

5.5.2 Subtask 5b—Fish Tissue Quality Investigation

This subsection presents an evaluation of the fish tissue data (salmonid and forage fish) through a tabulated comparison of each mine's data to COPC thresholds, and visually with SWDs of flowing systems (i.e., no ponds are presented).

5.5.2.1 Data comparison to COPC thresholds

Refer to the first two paragraphs of Section 5.1.2.1 for instructions on how to interpret the data comparison to COPC thresholds tables.

Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, and Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results* compare the tabulated Phase I SI aquatic and riparian media results (including surface water, sediment, salmonid fish, forage fish, benthic macroinvertebrates, riparian soil, and riparian vegetation) to the COPC thresholds indicated on the respective table. The comparison is discussed below by mine.

P4 sampled all stream stations (i.e., all stations were electro-fished and no assumptions were made). However, fish were not obtained/present at all stations likely due to insufficient aquatic habitat to support fish (see RBS score and the logistic regression of the fish model). In stream segments where salmonids and forage fish were sampled, the aquatic and riparian media did not have exceedances of the COPC threshold values.

<u>Enoch Valley Mine (EVM)</u>

In summary, reviewing Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, for salmonid fish, no COPC thresholds are exceeded for salmonid fish that are potentially attributable to EVM.

For forage fish, one vanadium threshold exceedance (MST131) is potentially attributable to EVM. No other COPC thresholds are exceeded for forage fish that are potentially attributable to EVM.

Henry Mine (HM)
In summary, reviewing Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, for salmonid fish and forage fish, no COPC thresholds are exceeded.

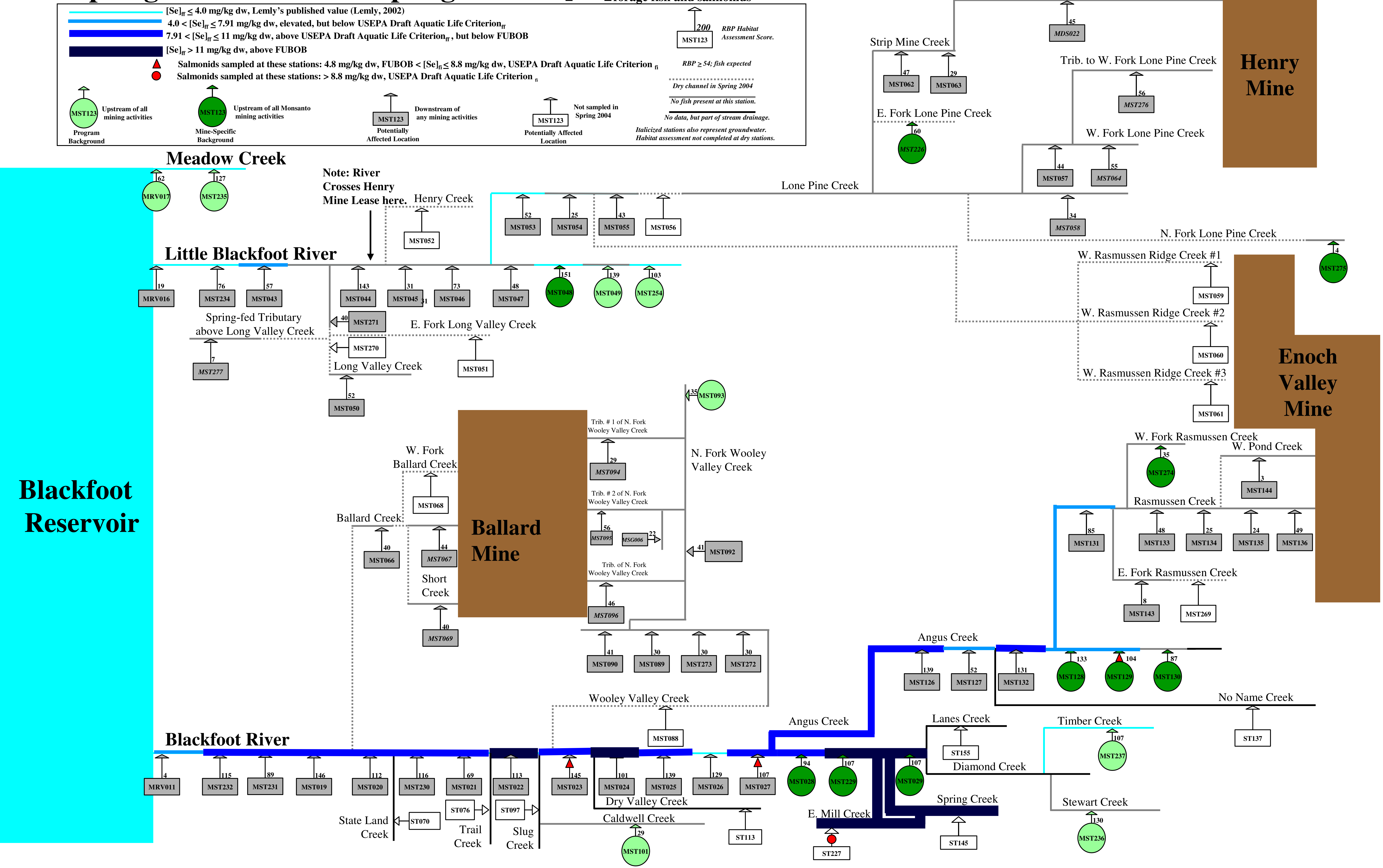
Ballard Mine (BM)
In summary, reviewing Table 5-3, *Henry Mine—Aquatic and Riparian Media Censored Results*, for salmonid fish and forage fish, no COPC thresholds are exceeded.

5.5.2.2 Spatial Wire Diagrams (SWDs)

Refer to the first two paragraphs of Section 5.1.2.2 for instructions on how to interpret the SWDs.

The forage fish and salmonid SWDs are presented in Appendix E by COPC, and the RBP Habitat Assessment Score (see Section 5.5.1 above) is provided for each station on the fish SWDs. Fish results from each sampling station were compared to the threshold ranges indicated on each SWD. For discussion purposes, the selenium forage fish and salmonid SWD is also presented below because selenium is the most prevalent COPC. Note: salmonids were only analyzed for selenium in 2004.

Spring 2004 Stream Sampling Results [Se]$_{forage\ fish\ and\ salmonids}$



Enoch Valley Mine (EVM)
Reviewing the selenium SWD for fish at EVM, no stations are above USEPA draft selenium criterion (7.9 mg/kg dw), but below the FUBOB (11 mg/kg dw) and one station (MST131) is above Lemly's published value (4.0 mg/kg dw; Lemly, 2002) but below the USEPA draft selenium criterion (7.9 mg/kg dw). No forage fish or salmonids were obtained from most of the sampling stations within close proximity to EVM. However, as the rapid bioassessment score (RBS) habitat score indicates, this is due to the poor fish habitat at these stations. The only COPC threshold exceedance found at an EVM influenced station was found at MST131 for vanadium.

Elevated selenium in forage fish is observed in Angus Creek (MST126, MST127, and MST132); however, two upstream EVM-specific background stations (MST128 and MST129) also reported elevated selenium in forage fish. Elevated selenium in salmonids is observed at one station (MST129) in Angus Creek, above FUBOB (4.8 mg/kg dw), but below the proposed USEPA draft selenium criterion (8.8 mg/kg dw). However this station is an upstream EVM-specific background station.

Henry Mine (HM)
Reviewing the SWDs for fish at HM, almost no forage fish, and absolutely no salmonids, were obtained from the sampling stations within close proximity to HM. However, as the RBS habitat score indicates, this is due to the poor fish habitat at these stations. Where forage fish were obtained (MST053), the result is below the lowest forage fish threshold for all COPCs.

Ballard Mine (BM)
Reviewing the SWDs for fish at BM, no forage fish or salmonids were obtained from the sampling stations within close proximity to BM. However, as the RBS habitat score indicates, this is due to the poor fish habitat at these stations.

Little Blackfoot River
Reviewing the SWD for fish along the Little Blackfoot River, no COPC exceedances for forage fish are present except one selenium result (MST043) is elevated above Lemly's published value (4.0 mg/kg dw) and the proposed draft selenium criterion (7.9 mg/kg dw). No COPC exceedances were found in salmonids along the Little Blackfoot River.

Blackfoot River
Reviewing the selenium SWD for fish along the Blackfoot River, most stations sampled for forage fish (MST019, MST020, MST021, MST023, MST025, MST027, MST230, MST231, MST232, MST, MST) are above the proposed USEPA draft selenium criterion (7.9 mg/kg dw), but below the FUBOB (11 mg/kg dw). There are also two sporadic station results (MST022 and MST024) above the FUBOB (11 mg/kg dw), one is below the confluence of Slug Creek and one is above the confluence of Dry Valley Creek. However, three stations above all P4 mining activities (mine-specific background) are elevated in selenium; one station (MST028)is above the USEPA proposed draft selenium criterion (7.9 mg/kg dw), but below the FUBOB (11 mg/kg dw), and two station results (MST029, and MST229) are above the FUBOB (11 mg/kg dw). In addition, historical results of elevated selenium in forage fish from non-P4 mining activities are observed at East Mill Creek and Spring Creek.

Two stations (MST023 and MST027) sampled for salmonids were also found to be above FUBOB (4.8 mg/kg dw) but below the proposed USEPA draft selenium criterion (8.8 mg/kg dw). However, both of these stations are downstream of the confluences of E. Mill Creek and Spring Creek, both of which have elevated selenium concentrations from non-P4 mining activities.

No other COPCs have any station results along the Blackfoot River exceed any thresholds, except for a few sporadic mid-level vanadium exceedances (MST019, MST021, and MST024).

5.5.3 Other Aquatic Ecological Investigations—Benthic Macroinvertebrates

This subsection presents an evaluation of benthic macroinvertebrates through a tabulated comparison of each mine's data to COPC thresholds, and visually with SWDs of flowing systems (i.e., no ponds are presented).

5.5.3.1 Data comparison to COPC thresholds

Refer to the first two paragraphs of Section 5.1.2.1 for instructions on how to interpret the data comparison to COPC thresholds tables.

Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, and Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results* compare the tabulated Phase I SI aquatic and riparian media results (including surface water, sediment, salmonid fish, forage fish, benthic macroinvertebrates, riparian soil, and riparian vegetation) to the COPC thresholds indicated on the respective table. The comparison is discussed below by mine below. Some reporting limits are elevated due to limited sample volume.

Enoch Valley Mine (EVM)

In summary, reviewing Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, for benthic macroinvertebrates, no results were above the selenium threshold and potentially attributable to EVM.

Henry Mine (HM)

In summary, reviewing Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, for benthic macroinvertebrates, no results were above the selenium threshold and potentially attributable to HM.

Ballard Mine (BM)

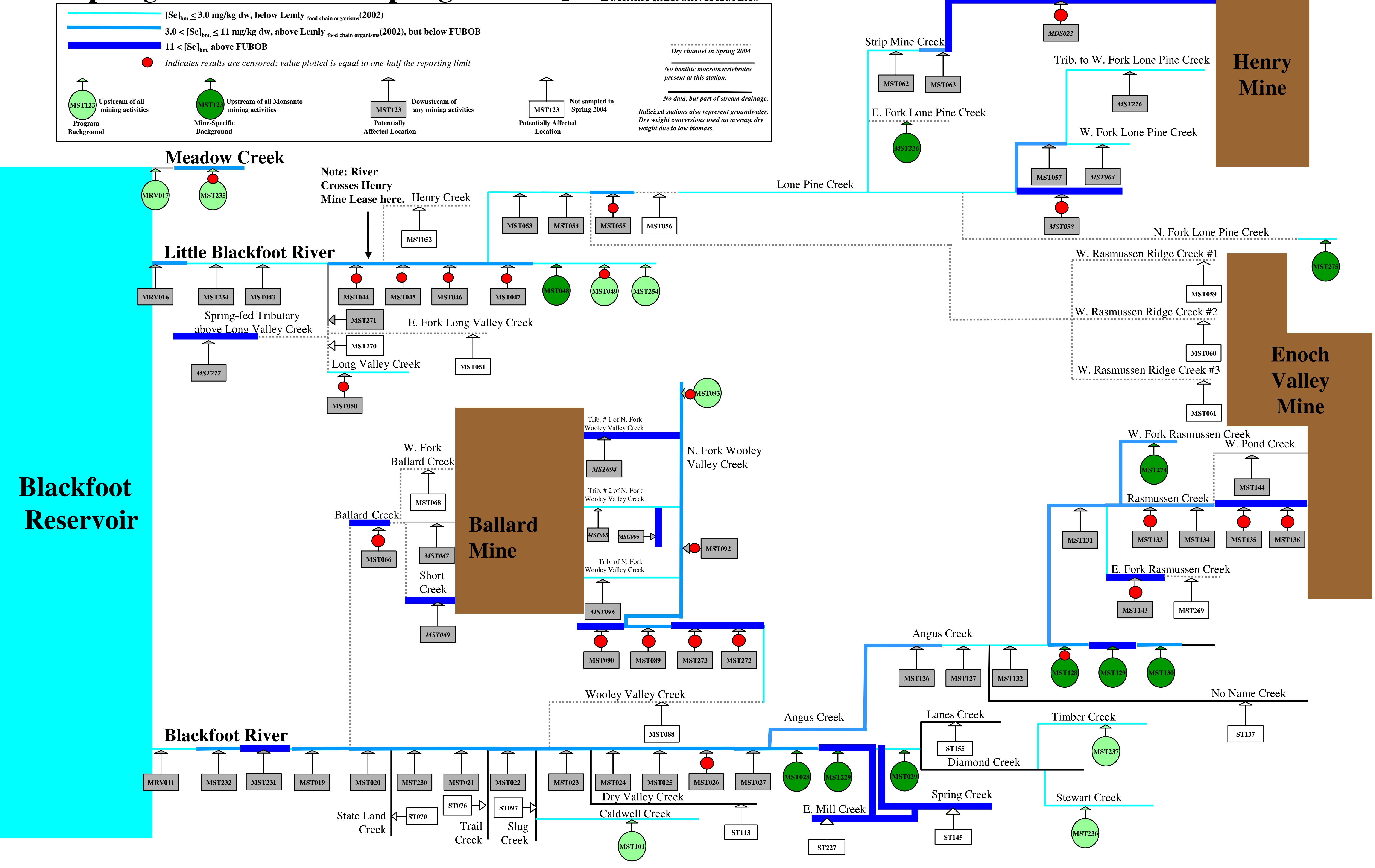
In summary, reviewing Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results*, for benthic macroinvertebrates, two stream stations (MST069 and MST094) and one spring station (MSG006) were above the selenium threshold and potentially attributable to BM.

5.5.3.2 Spatial Wire Diagrams (SWDs)

Refer to the first two paragraphs of Section 5.1.2.2 for instructions on how to interpret the SWDs.

The benthic macroinvertebrate selenium SWD is presented in Appendix F. Benthic macroinvertebrate results from each sampling station were compared to the threshold ranges indicated on the SWD. For discussion purposes, the selenium benthic macroinvertebrate SWD is also presented below.

Spring 2004 Stream Sampling Results $[Se]_{benthic\ macroinvertebrates}$



Enoch Valley Mine (EVM)
Reviewing the selenium SWD for benthic macroinvertebrates at EVM, three stations (MST135, MST136, and MST143) appear to be above the FUBOB (11 mg/kg dw) in close proximity to EVM, however, all three exceedances were based on one-half of the laboratory detection limit for the non-detect results. Three stations (MST131, MST133, and MST134) are above Lemly's published selenium value for food chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw), however, one of the three stations is based on one-half of the laboratory detection limit for the non-detect results. Also note, mine-specific background stations (MST128, MST130, and MST274) are above Lemly's published selenium value for food chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw), with one of the three stations being based on one-half of the laboratory detection limit for the non-detect results (MST128). One additional mine-specific background station (MST129) is above the FUBOB (11 mg/kg dw).

In summary, based on current data it appears as though EVM is not contributing to the elevated selenium levels [between Lemly's published selenium value for food chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw)] observed in the Blackfoot River and lower Angus Creek. Several stations downstream of Rasmussen Creek (such as MST127 and MST132) are not elevated in benthic macroinvertebrates (at any threshold), mine-specific background concentrations are elevated, and the majority of elevations in the proximity of EVM are based on non-detect results.

Henry Mine (HM)
Reviewing the selenium SWD for benthic macroinvertebrates at HM, two stations (MST058 and MDS022) appear to be above the FUBOB (11 mg/kg dw) in close proximity to HM, however, both exceedances were based on one-half of the laboratory detection limit for the non-detect results. Two stations (MST057 and MST063) are above Lemly's published selenium value for food chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw).

In summary, based on current data it appears as though HM is not contributing to the elevated selenium levels (between Lemly's published selenium value for food chain organisms [3.0 mg/kg dw] but below the FUBOB [11 mg/kg dw]) observed in the Little Blackfoot River (based on non-detects) because several stations (MST062, MST053, and MST054) along Strip Mine Creek and Lone Pine Creek (downstream of HM) are not elevated in benthic macroinvertebrates (at any threshold), and because numerous elevations in the proximity of HM are based on non-detect results.

Ballard Mine (BM)
Reviewing the selenium SWD for benthic macroinvertebrates at BM, seven stations (MST066, MST069, MST089, MST090, MST094, MST272, and MST273) appear to be above the FUBOB (11 mg/kg dw) in close proximity to BM, however, four of the seven exceedances were based on one-half of the laboratory detection limit for the non-detect results. Two stations (MST089 and MST092) are above Lemly's published selenium value for food chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw), however, both stations are based on one-half of the laboratory detection limit for the non-detect results. Also note, one station (MST093) above all mining activities (program background) is also above Lemly's published selenium value for food

chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw), based on a non-detect result.

In summary, based on current data it appears as though BM is not contributing to the elevated selenium levels (between Lemly's published selenium value for food chain organisms [3.0 mg/kg dw] but below the FUBOB [11 mg/kg dw]) observed in the Blackfoot River because both Ballard Creek and Wooley Valley Creek are intermittent streams, and the stream becomes dry before reaching the Blackfoot River for all years of the area-wide and mine-specific investigations, including May 2006 which was determined by IDEQ to be an above average water year. Also, most elevations in the proximity of BM are based on non-detect results.

Little Blackfoot River

Reviewing the selenium SWD for benthic macroinvertebrates along the Little Blackfoot River, five stations (MST044, MST045, MST046, MST047, and MST055) appear to be above Lemly's published selenium value for food chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw), however, four of the five are non-detect results and are based on one-half of the reporting limit. Therefore, based on current data it appears as though benthic macroinvertebrates in the Little Blackfoot River do not appear to have elevated selenium concentrations.

Blackfoot River

Reviewing the selenium SWD for benthic macroinvertebrates along the Blackfoot River, the majority of stations along the river are above Lemly's published selenium value for food chain organisms (3.0 mg/kg dw) but below the FUBOB (11 mg/kg dw), with one station (MST231) along the lower stretches of the river that is above the FUBOB (11 mg/kg dw). Based on current data, and since two mine-specific background stations (MST229 and MST028) are also elevated (one within each exceedance category), and because it does not appear EVM (via Angus Creek) or Ballard Mine (via Ballard Creek or Wooley Valley Creek) are contributing to the elevations in the Blackfoot River, P4 is not likely contributing to the elevations observed in the Blackfoot River.

5.6 TASK 6: TERRESTRIAL ECOLOGICAL INVESTIGATION

This task included five subtasks. Three Subtasks, 6a, 6b, and 6f discussed below, involved field sampling.

5.6.1 Subtask 6a—Habitat Assessment of Ponds, Wetlands, and Non-Fish Bearing Streams

Note, for the purposes of this data evaluation, one-half the reporting limit (RL/2) is substituted for those COPC concentrations that are censored at the reporting limit (< RL).

As the ponds, wetlands, and non-fish bearing streams within the study area pose no direct threat to fish, their ecological function is largely riparian oriented. Thus, it is riparian exposure pathways that are of primary concern in such systems. For this reason P4 chose to conduct riparian habitat assessments of these systems.

The stream habitat assessment results presented in Subsection 5.5.1 were used to identify stream stations that do not support fish populations. After surveying the wetlands in the study area, we concluded that there were no wetlands present that were not already classified as either a pond or flowing system (e.g., non-fish bearing stream, seep, or spring). And ponds included all stock ponds, runoff control ponds, and mine pit ponds located on or adjacent to Enoch Valley, Henry, or Ballard mines.

The riparian habitat assessments were conducted in two parts—one for ponds, and one for non-fish bearing stream stations (including seeps and springs). The assessments were performed by an ornithologist with a doctorate in the field and vast experience in performing ecological habitat assessments. As no protocol could be found to fit the needs of this investigation (all protocols available are tailored to assessing habitats of threatened or endangered species), the ornithologist developed a detailed protocol.

The assessment of each station consisted of detailed observation of the area, which typically took perhaps 30 to 45 minutes. Usage of the habitat—or potential usage in situations where current mine structures were the only thing prohibiting such usage—were recorded as the presence or absence of a particular assemblage of species, where each assemblage more or less represents a guild of species exploiting the habitat of interest in a similar manner. The resulting data matrices for ponds and non-fish bearing streams are presented in Tables 5-6 and 5-7.

A principal components analysis (PCA) was performed on each data matrix in an attempt to condense the information into fewer variables. The resulting principal axis scores at each station, for those principal axes found to contain significant information, were then subjected to a minimum variance cluster analysis to classify the stations. Please refer to Appendix N for further discussion regarding the methods of this analysis.

For the ponds, PCA yields only one significant principal axis. High principal component #1 (PC1) scores represent better habitat for all assemblages except birds that forage at the water's edge. The assemblages that predominantly define this axis are aerial foraging birds, small mammals, and marsh-nesting birds. In short, a PC1 score can be regarded as a habitat quality score.

Table 5-6
Pond Riparian Habitat Assessment Matrix

	Amphibians	Swimming birds	Marsh-nesting birds	Cavity-nesting birds	Birds that forage at water's edge	Aerial-foraging birds	Open cup-nesting birds	Small mammals	Water-dependent, medium-sized mammals	Upland, medium-sized mammals	Game mammals	Livestock
Pond	AM	SB	MB	CN	EF	AF	ON	SM	WM	UM	GM	LS
MSP010	1	1	0	1	0	0	1	0	0	0	1	1
MSP011	1	0	0	1	1	0	1	0	0	1	1	1
MSP012	1	0	0	1	0	0	1	1	0	1	1	1
MSP014	1	1	1	1	1	1	1	1	0	1	1	1
MSP015	1	1	0	1	1	0	1	0	0	1	1	1
MSP016	1	1	0	1	0	0	1	1	0	1	1	1
MSP017	1	1	1	1	1	1	1	1	0	1	1	1
MSP018	1	1	1	1	1	1	1	1	0	1	1	1
MSP019	1	1	0	1	0	1	0	1	0	1	1	1
MSP020	1	1	1	1	1	1	1	1	0	1	1	1
MSP021	1	1	0	1	0	1	1	1	0	1	1	1
MSP022	1	1	0	1	1	1	1	1	0	1	1	1
MSP023	1	1	1	1	0	1	1	1	0	1	1	1
MSP031	1	1	1	1	1	1	1	1	0	1	1	1
MSP055	0	0	0	0	1	0	0	0	0	0	0	0
MSP059	1	1	0	0	1	0	1	0	0	1	1	1
MSP062	1	0	0	1	1	0	1	1	0	1	1	1

A cluster analysis of the PC1 scores shows that the 17 ponds can be grouped into four distinct categories. Figure 5-18 is a plot of the PC1 scores identifying the four clusters, and a clustering dendrogram is provided in Figure 5-19. Clusters #1 and #2 can be regarded as containing ponds with high quality riparian habitat, while clusters #3 and #4 contain ponds with low quality riparian habitat. While selenium in various riparian environmental media is significantly and positively correlated, PC1 is correlated only with selenium in sediment and this correlation is weak and negative. It thus appears that selenium contamination has no significant effect upon habitat quality. Rather, as in the case of the in-stream fish habitat assessment, physical factors are primarily responsible for defining habitat quality.

To avoid an adverse environmental impact, consideration should be given to preserving ponds in clusters #1 and #2. On the contrary, it appears that ponds in clusters #3 and #4 could be eliminated without causing an adverse impact on their surrounding ecologies.

For the non-fish bearing streams, PCA yields two significant principal axes. High PC1 scores represent better habitat for amphibians and swimming birds. High PC2 scores represent better habitat for game mammals and small mammals. In other words, stations with high PC1 scores have relatively better aquatic-type habitat, where those with high PC2 scores have relatively better terrestrial-type habitat.

Table 5-7: Stream Riparian Habitat Assesssment Data Matrix													
		Amphibians	Swimming birds	Marsh-nesting birds	Cavity-nesting birds	Birds that forage at water's edge	Aerial-foraging birds	Open cup-nesting birds	Small mammals	Water dependent medium-sized mammals	Upland medium-sized mammals	Game mammals	Livestock
Station	Category	AM	SB	MB	CN	EF	AF	ON	SM	WM	UM	GM	LS
MDS022	ponded seep	1	1	1	0	0	1	1	1	0	1	1	1
MSG006	spring	0	0	1	0	0	1	1	1	0	1	1	1
MST044	stream	0	0	0	1	0	1	1	1	0	1	1	1
MST045	ponded stream	1	1	0	1	1	1	0	1	0	1	1	1
MST046	stream	1	1	0	0	0	1	1	0	0	1	0	1
MST047	stream	1	1	0	0	0	1	1	0	0	1	0	1
MST049	ponded stream	1	1	0	1	0	0	1	1	0	1	1	1
MST050	ponded stream	1	1	0	1	1	1	0	1	0	1	1	1
MST054	stream	1	0	0	0	0	1	0	0	0	0	0	1
MST055	stream	1	0	0	0	0	1	1	0	0	0	0	1
MST057	ponded stream	1	0	0	1	0	1	1	1	0	1	1	1
MST058	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST062	stream	0	0	0	0	0	1	0	0	0	0	0	1
MST063	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST064	stream	1	0	1	0	0	1	1	1	0	1	1	1
MST066	stream	0	0	0	0	0	1	1	0	0	1	0	1
MST067	stream	0	0	0	0	0	1	1	1	0	1	0	1
MST069	stream	0	0	0	0	0	1	1	1	0	1	0	1
MST089	stream	0	0	0	0	0	1	0	1	0	1	0	1
MST090	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST092	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST093	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST094	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST095	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST096	ponded stream	1	1	1	0	0	0	1	1	0	1	1	1
MST101	ponded stream	0	0	0	1	1	1	1	0	0	1	1	1
MST130	stream	0	0	0	1	0	1	1	1	0	1	1	1
MST133	semi-ponded stream	0	1	0	0	0	0	1	1	0	1	1	1
MST134	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST135	stream	0	0	1	0	0	1	1	1	0	1	1	1
MST136	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST143	semi-ponded stream	0	1	0	0	0	1	1	0	0	1	1	1
MST144	stream	0	0	0	0	0	1	1	1	0	1	1	1
MST236	ponded stream	1	0	0	1	0	0	0	0	0	1	1	1
MST272	stream	0	0	1	0	0	1	1	1	0	1	1	1
MST273	stream	0	0	0	0	0	1	0	1	0	1	0	1
MST274	stream	0	0	0	0	0	1	1	0	0	1	1	1
MST275	ponded stream	1	1	0	1	1	1	1	0	0	1	1	1
MST276	stream	1	0	1	0	0	1	1	1	0	1	1	1
MST277	stream	1	0	0	0	0	1	1	0	0	0	1	1

Figure 5-18
Pond Riparian Habitat Assessment Cluster Analysis of P1 Scores

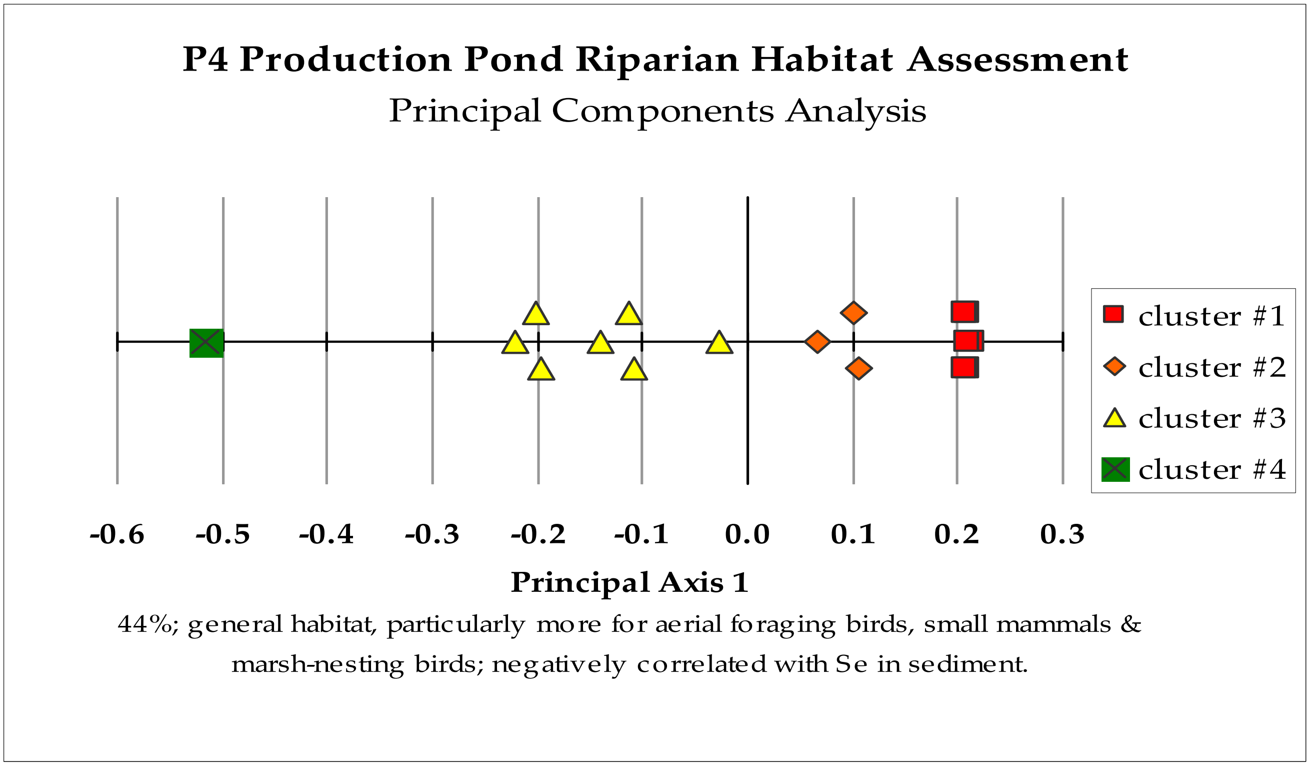
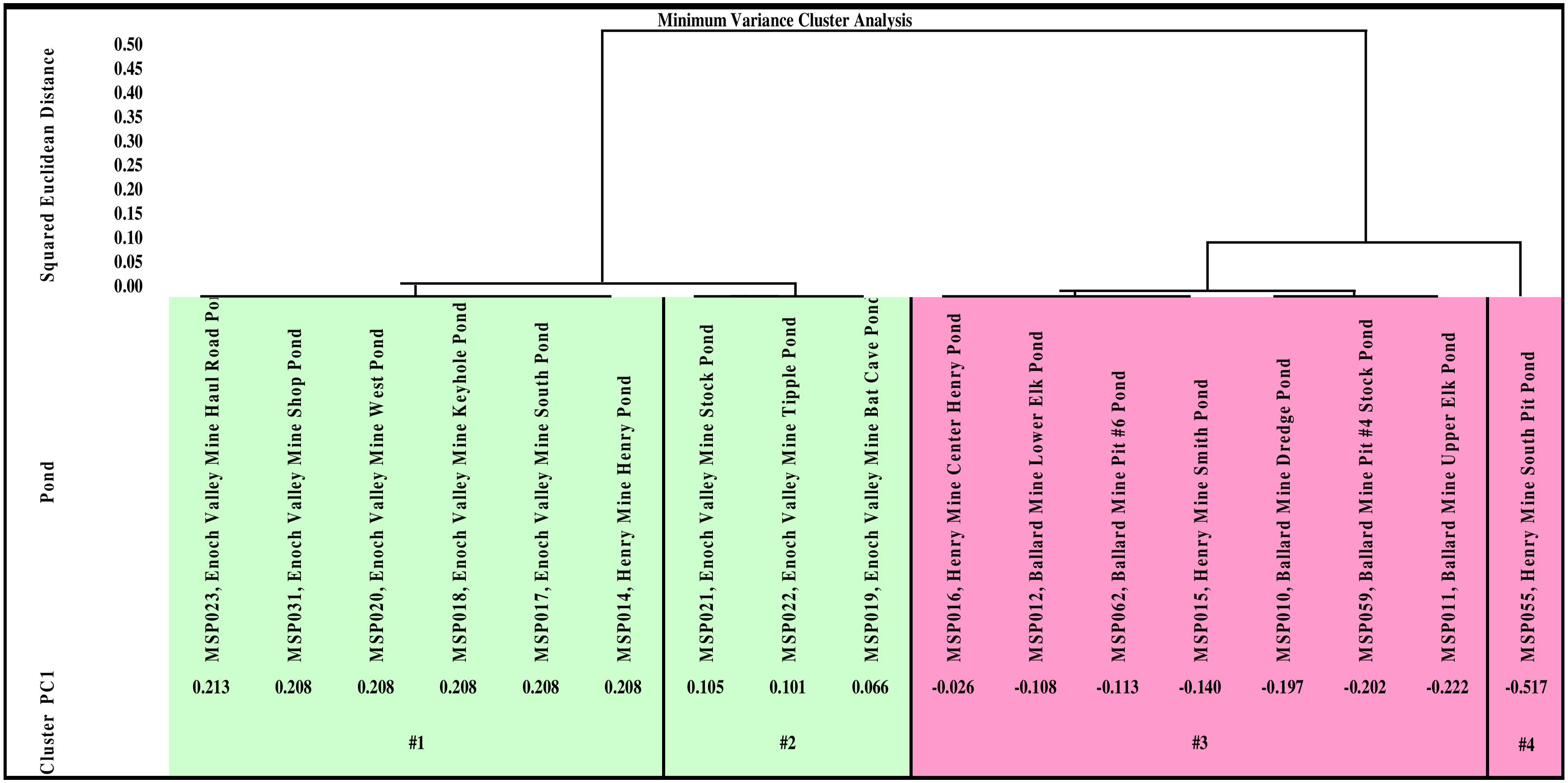


Figure 5-19: Pond Riparian Habitat Assessment Clustering Dendrogram



A cluster analysis of the principal component scores on the two significant axes shows that the 40 non-fish bearing stream stations can be grouped into four distinct categories.

Figure 5-20 is a plot of the PC1 and PC2 scores identifying the four clusters, and a clustering dendrogram is provided in Figure 5-21. It appears that the four clusters can be interpreted as follows:

- Cluster #1—high quality aquatic and terrestrial habitat;
- Cluster #2—high quality aquatic, but low quality terrestrial habitat;
- Cluster #3—low quality aquatic, but high quality terrestrial habitat; and,
- Cluster #4—low quality aquatic and terrestrial habitat.

Given the nature of these systems, interpreting low scores as indicative of poor quality habitat may be too harsh. Low scores are more likely indicative of a limited amount of habitat type present. Small streams just do not generate much riparian habitat. In fact, most of the ponded streams have higher scores, which may be a function of a pond having a larger area because it is a two-dimensional, rather than one-dimensional, feature in the environment. Thus, the assessment of non-fish bearing riparian habitats does not point to any such habitats being of utterly poor quality.

Figure 5-20: Stream Riparian Habitat Assessment Cluster Analysis of P1 Scores

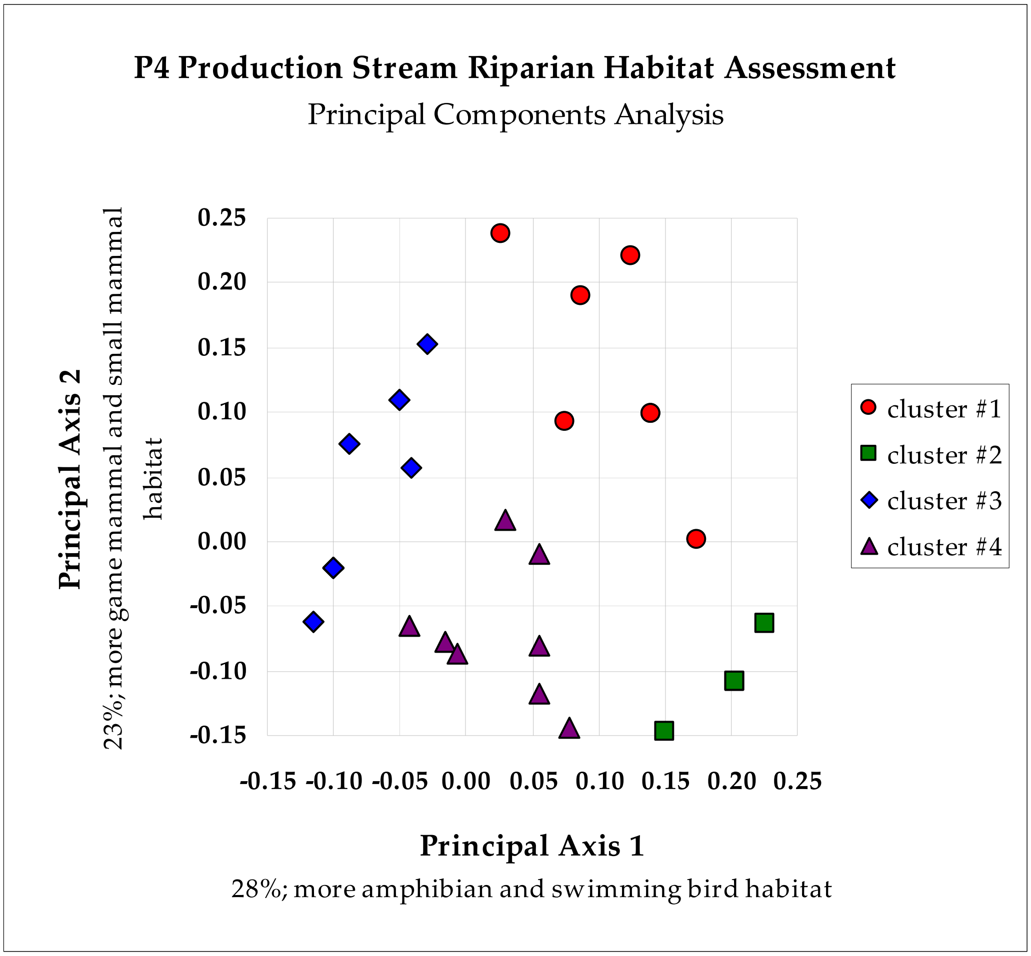
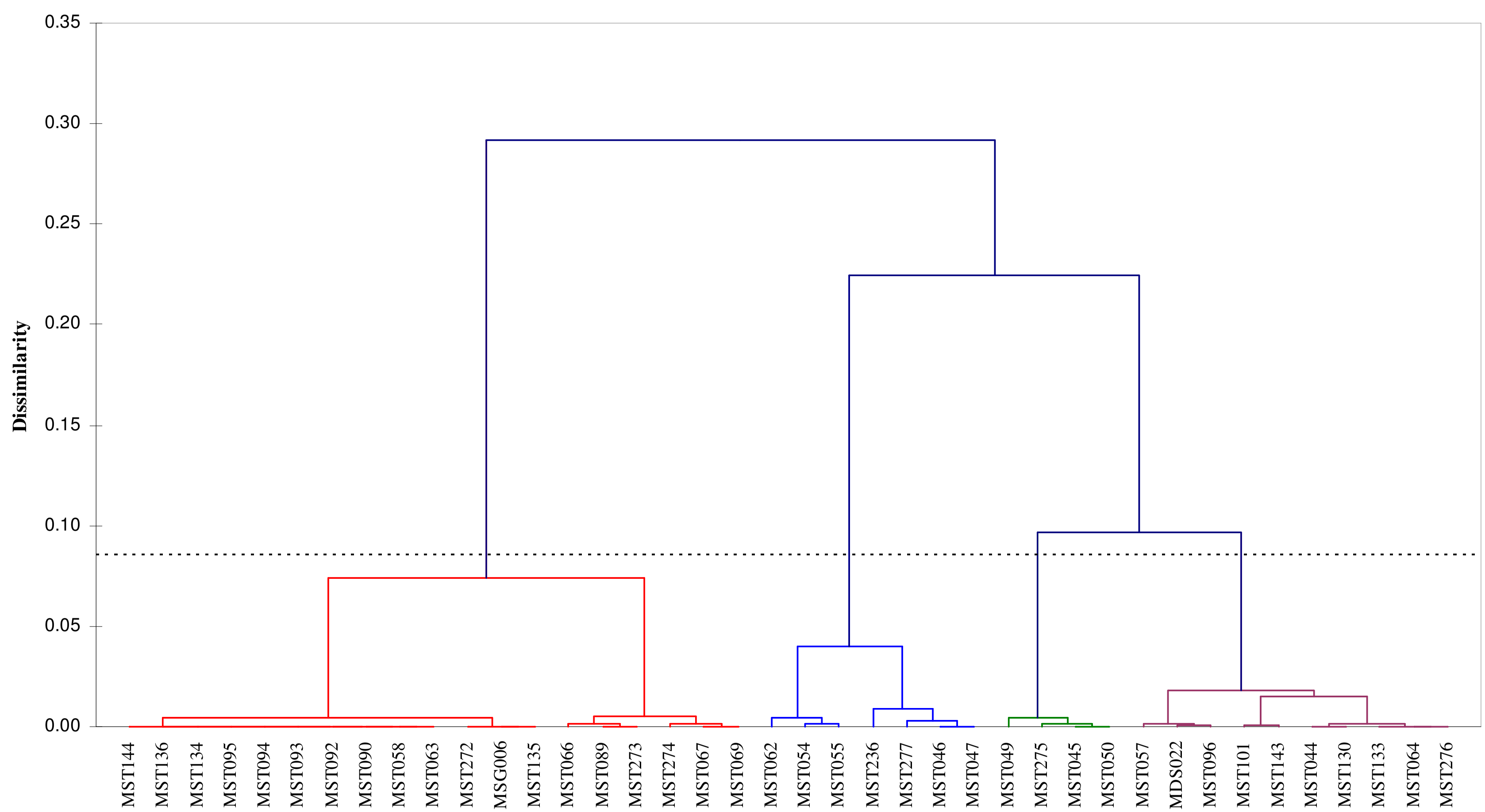


Figure 5-21: Stream Riparian Habitat Assessment Clustering Dendrogram



5.6.2 Subtask 6b—Characterization of Extent of Riparian Zone Vegetation Contamination at Streams, Ponds, Seeps, Springs, and Wetlands

This subsection presents an evaluation of the riparian vegetation data through a tabulated comparison of each mine's data to COPC thresholds, and visually with SWDs of flowing systems (i.e., no ponds are presented).

5.6.2.1 Data comparison to COPC thresholds

Refer to the first two paragraphs of Section 5.1.2.1 for instructions on how to interpret the data comparison to COPC thresholds tables.

Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, and Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results* compare the tabulated Phase I SI aquatic and riparian media results (including surface water, sediment, salmonid fish, forage fish, benthic macroinvertebrates, riparian soil, and riparian vegetation) to the COPC thresholds indicated on the respective table. The comparison is discussed by mine below.

__Enoch Valley Mine (EVM)__

In summary, reviewing Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, for riparian vegetation, no exceedances of COPC thresholds are present at stream or spring stations (except two molybdenum threshold exceedances at stream stations MST059 and MST061) potentially attributable to EVM. One of two seep stations (MDS025) exceeded the selenium and molybdenum thresholds and five pond stations (MSP017, MSP018, MSP019, MSP020, and MSP021) exceeded the selenium threshold while only one other pond station (MSP031) exceeded the molybdenum threshold.

__Henry Mine (HM)__

In summary, reviewing Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, for riparian vegetation, no exceedances of COPC thresholds are present at stream, spring, or seep stations (except three molybdenum threshold exceedances at stream stations MST059, MST061, and MST052) potentially attributable to HM. Three pond stations (MSP015, MSP016, and MSP055) exceeded the selenium threshold and one of the three also exceeded the molybdenum threshold (MSP055).

__Ballard Mine (BM)__

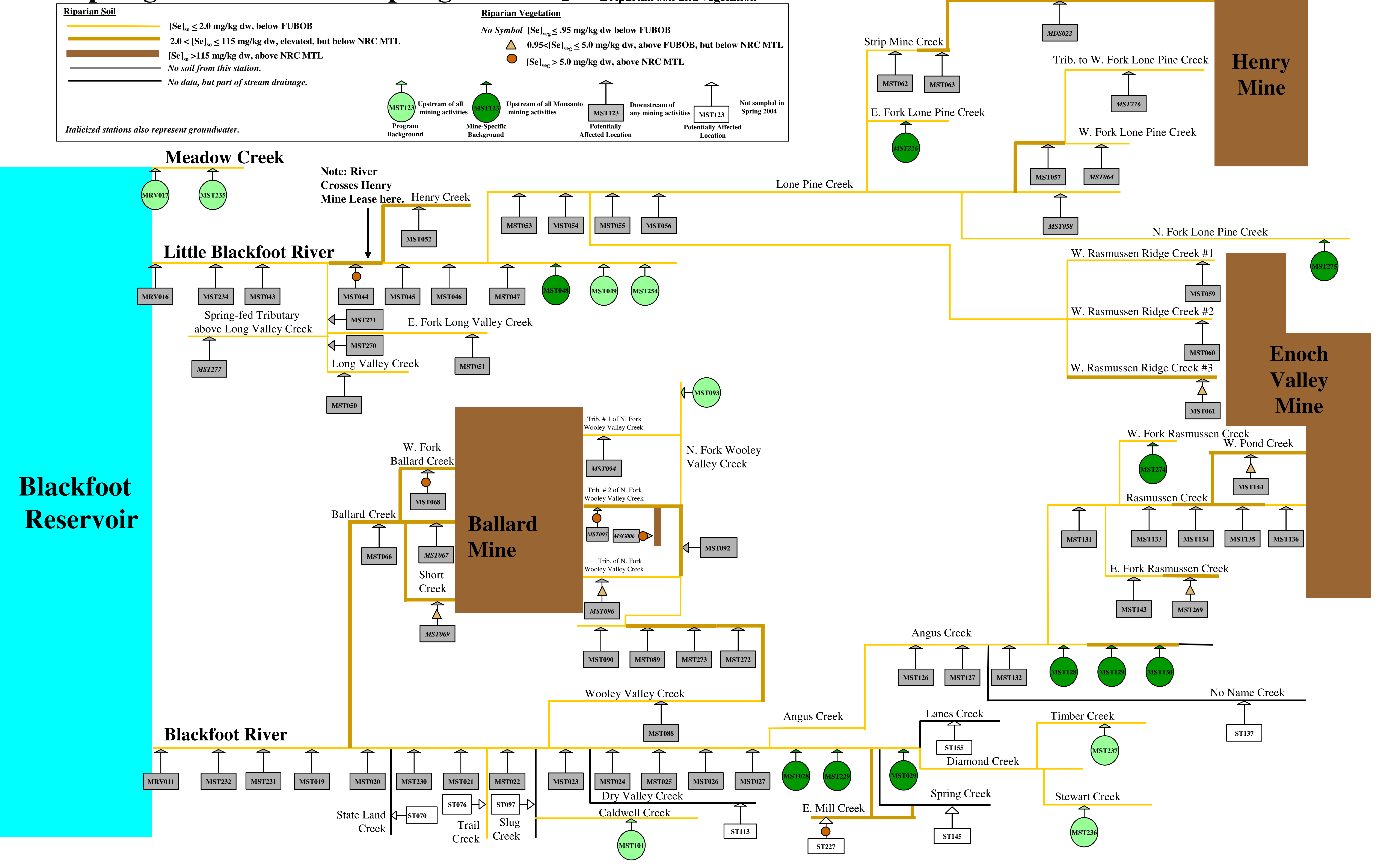
In summary, reviewing Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results*, for riparian vegetation, no exceedances of COPC thresholds are present at stream, stations (except two selenium threshold exceedances MST068 and MST095) potentially attributable to BM. Three seep (MDS031, MDS032, and MDS033), two spring (MSG003 and MSG006), and five pond stations (MSP010, MSP011, MSP012, MSP013, and MSP059) exceeded the selenium threshold with a few other cadmium and/or molybdenum threshold exceedances (MSP012, MSP059, and MSP062).

5.6.2.2 Spatial Wire Diagrams (SWDs)

Refer to the first two paragraphs of Section 5.1.2.2 for instructions on how to interpret the SWDs.

The riparian soil and vegetation SWDs are presented in Appendix G by COPC. Riparian vegetation results from each sampling station were compared to the threshold ranges indicated on each SWD. For discussion purposes, the selenium riparian vegetation SWD is also presented below because selenium is the most prevalent COPC.

Spring 2004 Stream Sampling Results [Se]$_{\text{riparian soil and vegetation}}$



Enoch Valley Mine (EVM)
Reviewing the selenium SWD for riparian vegetation at EVM, three stations (MST061, MST144, and MST269) are above the FUBOB (0.95 mg/kg dw) but below the NRC MTL (5.0 mg/kg dw) within close proximity to EVM. Other COPCs also have threshold exceedances as illustrated on the respective SWDs (Mo: MST059, MST060, MST061; Zn: MST269).

In summary, although several exceedances of COPC thresholds for riparian vegetation are observed in close proximity to EVM, elevated selenium concentrations are not being observed downstream (via Angus Creek) to the Blackfoot River or downstream (via Lone Pine Creek) to the Little Blackfoot River.

Henry Mine (HM)
Reviewing the SWD's for riparian vegetation at HM, only one station (MST044) is above the selenium NRC MTL (5.0 mg/kg dw), however Molybdenum does have a few station exceedances. MDS022 and MST044 are above FUBOB (3.8 mg/kg dw) but below the NRC MTL (5.0 mg/kg dw) and MST052 is above the NRC MTL (5.0 mg/kg dw).

In summary, although several exceedances of COPC thresholds for riparian vegetation are observed in close proximity to HM, elevated COPC concentrations are not being observed consistently downstream (via Lone Pine Creek) to the Little Blackfoot River. Therefore, based on current data it appears as though HM is not contributing significant levels of riparian vegetation COPCs to the Little Blackfoot River.

Ballard Mine (BM)
Reviewing the selenium SWD for riparian vegetation at BM, two stations (MST069 and MST096) is above the FUBOB (0.95 mg/kg dw) but below the NRC MTL (5.0 mg/kg dw) and three stations (MST068, MST095, and MSG006) are above the NRC MTL (5.0 mg/kg dw). No other COPCs have threshold exceedances.

In summary, although several exceedances of the Selenium threshold for riparian vegetation are observed in close proximity to BM, elevated COPC concentrations are not being observed consistently downstream (via Ballard Creek or Wooley Valley Creek) to the Blackfoot River. Therefore, based on current data it appears as though BM is not contributing significant levels of riparian vegetation COPCs to the Blackfoot River.

Little Blackfoot River
Reviewing the SWD's for riparian vegetation along the Little Blackfoot River, one station (MST044) is above the selenium NRC MTL (5.0 mg/kg dw) and one station (MST044) is above the molybdenum FUBOB (3.8 mg/kg dw) but below the NRC MTL (5.0 mg/kg dw), both are located at a station near or downstream of HM. No other COPC thresholds are exceeded.

Blackfoot River
Reviewing the SWD's for riparian vegetation along the Blackfoot River, no COPC thresholds are exceeded. Therefore, based on current data it appears as though P4 is not contributing to any increased levels of COPCs in riparian vegetation along the Blackfoot River.

5.6.3 Subtask 6c—Evaluate Potential Replacements for Alfalfa in Reclamation Seed Mix

This task will be reported in the comprehensive SI report.

5.6.4 Subtask 6d—Identification and Location of Known Selenium Absorber Species

This task will be reported in the comprehensive SI report.

5.6.5 Subtask 6e—Veterinary Toxicology Panel on Livestock Utilization of Reclaimed Land

The veterinary toxicology panel, consisting of Merl F. Raisbeck, DVM, PhD, DABVT; Michael A. Smith, PhD; and, Patricia Talcott DVM, PhD, DABVT, was tasked to review existing data and information on livestock exposure to seleniferous vegetation on waste rock dumps to determine the following:

- Safe levels of selenium in vegetation to allow different livestock species (cattle, sheep, and horses) to graze the dumps, including any mitigating measures (i.e., grazing duration, water supply) as necessary;
- A recommendation for what concentration of selenium in waste rock dump vegetation would be safe for all livestock species to graze without restriction; and,
- Identify further data needs to allow these determinations to be refined.

The panel reported their review and findings in the document entitled *Grazing Reclaimed Minelands in SE Idaho* (Raisbeck, 2006), which was submitted to the agencies in April 2006. A brief summary of the panel's findings is as follows:

- Reduce mine-related selenium exposures to livestock by eliminating or replacing seleniferous water sources, promoting use of adjacent, non-seleniferous range, delaying the onset of animal exposure to the dumps later in the summer when selenium concentrations should be lower, and eliminate and replace selenium-accumulating forbs (such as alfalfa);
- Don't allow horses to graze dumps;
- Monitor trace element levels in all livestock with access to dumps; and,
- Conduct additional livestock and forage studies to monitor effectiveness of above measures and to determine site-specific acceptable levels of selenium in forage.

In summary, *Grazing Reclaimed Minelands in SE Idaho* is not a decision document. It thus contains no solutions, but rather presents potential intensive range management solutions that will be developed as an alternative, or as input to a variety of alternatives, to be evaluated in each mine-specific EE/CA.

5.6.6 Subtask 6f—Characterization of Waste Rock Dump Extent of Vegetation Contamination

This subtask is discussed in conjunction with *Subtask 4c—Characterization of Waste Rock Dump Extent of Soil Contamination* under Section 5.4.3 above because the data were evaluated together. Refer to Section 5.4.3 above for the evaluation.

5.6.7 Subtask 6g—Performance Monitoring of Non-Seleniferous Cap

This task will be reported in the comprehensive SI report.

5.6.8 Other Terrestrial Ecological Investigations—Seasonal Vegetation Investigation

Note, for the purposes of this data evaluation, one-half the reporting limit (RL/2) is substituted for those COPC concentrations that are censored at the reporting limit (< RL).

The purpose of this investigation was to determine if there are any seasonal differences of selenium concentrations in riparian vegetation and/or in upland vegetation growing on waste rock dumps. Vegetation samples were collected each month during the growing season, from May 2004 to October 2004 from selected waste rock dumps and riparian zones. The planning of this investigation is not included in the SI planning documents (PjtWPs, PjtFSPs, and SAP) because the USFS, through the IDEQ, requested the seasonal vegetation sampling after the planning documents had been approved, via a "Modifications to IDEQ's Previous Conditional Approval of SI Sampling Plans for Ballard, Henry and Enoch Valley Mines P4's (Monsanto's) Site-Specific Investigations". Therefore, P4 submitted a separate plan for such a study in the form of a memorandum entitled, "P4 Production SI Seasonal Vegetation Investigation" (B. Wright, MWH [Memorandum to Bob Geddes, Monsanto] June 28, 2004). Selected sampling locations and methods for this investigation are documented in the aforementioned memorandum.

The results of the seasonal vegetation investigation are provided below in Table 5-8, *Seasonal Vegetation-Censored Data (mg/kg dw)*.

Table 5-8
Seasonal Selenium Concentration in Vegetation - Censored Data (mg/kg dw)[a]

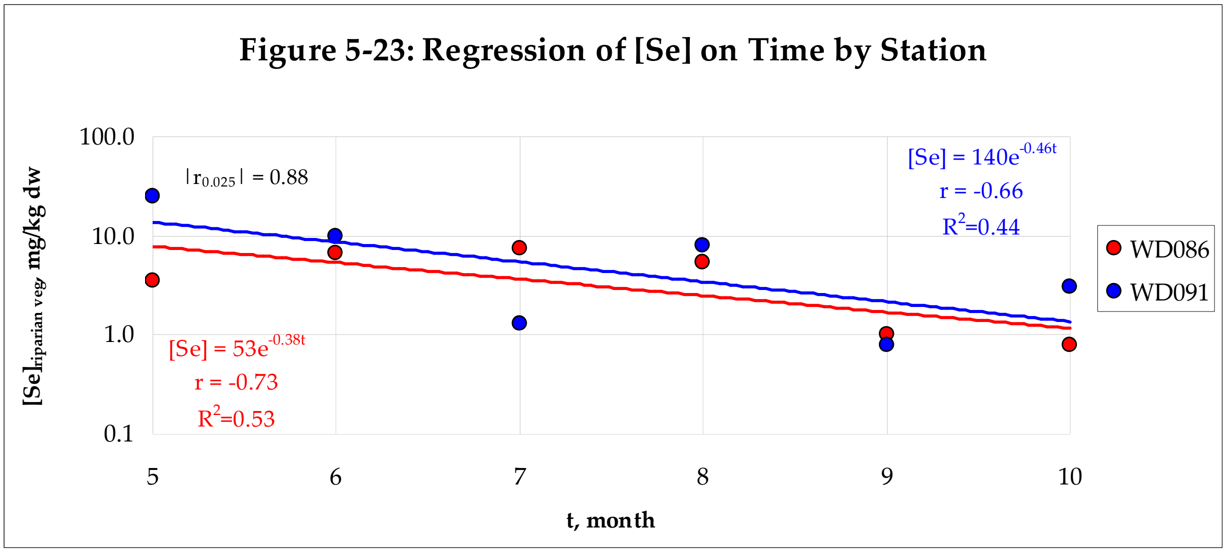
Station Name	Station ID	May	Jun	Jul	Aug	Sep	Oct
Blackfoot River, below Trail Creek	MST021	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Blackfoot River, below Angus Creek	MST027	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Blackfoot River, below Woodall Mtn. Creek	MST231	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Ballard Mine Pit #1 Overburden Dump #2	MWD081	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Henry Mine Center Waste Dump	MWD086	3.5	6.6	7.5	5.4	1.0	0.80
Enoch Valley Mine Waste Dump	MWD091	25	10	1.3	8.1	0.80	3.1

[a] Censored results are reported as less-than the reporting limit.

An evaluation of the results is detailed below. To normalize the seasonal vegetation data so that parametric statistical analysis can be conducted, the data were transformed according to the protocol detailed in the PgmQAP Appendix G—A Functional Upper Bound of Background (FUBOB), of the SAP. The data fit a lognormal distribution.

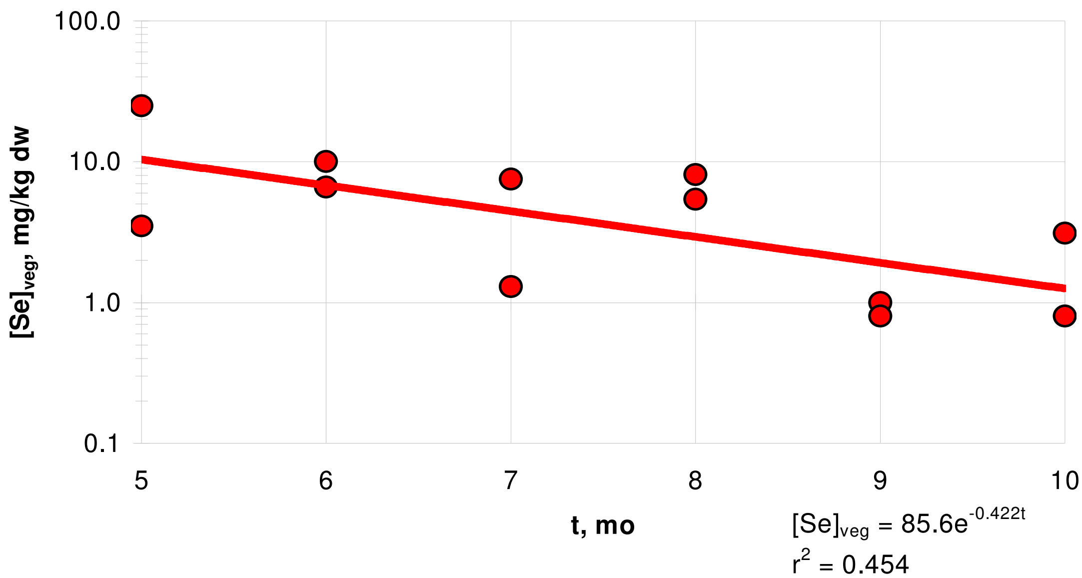
A two-way (sampling stations and seasons/months) analysis of variance (ANOVA) was then performed on the transformed values to determine differences among means of the transformed data from each group (stations and months). The two-way ANOVA shows no difference by month ($p < 0.00010$), but differences by station ($p = 0.23$). Only two stations (MWD086 and MWD091) show differences because all other stations are 100% censored at the laboratory reporting limit.

The transformed data of the two stations with detections were plotted versus time, see Figure 5-23, below. Both regressions on each station's results are not significant (-i.e., the slopes are not discernibly different from zero) as indicated by the r-values versus the critical r-value provided on Figure 5-23. Note: because there are no differences possible in 100% censored data, the results from the remainder of the stations were not plotted.



While the two-way ANOVA shows a difference in selenium concentration in vegetation between waste rock dumps, this difference appears to be driven by the fact that four stations have nothing but censored results. For the two dumps with data that are quantifiable, further analysis shows no difference between them. Thus, the six results from both these dumps can be combined to yield a data set with 12 values and nine degrees of freedom. A semi-logarithmic regression of selenium concentration in vegetation on time (in months) is significant, with time and concentration being negatively correlated; see Figure 5-24 below. Thus, the seasonal vegetation study has confirmed what has been observed elsewhere—that selenium concentrations tend to be highest in the spring and decrease over the growing season and into the period of senescence.

Figure 5-24: Combined Regression of [Se] on Time in Upland Vegetation



5.7 CHROMIUM SPECIATION INVESTIGATION

Note, for the purposes of this data evaluation, one-half the reporting limit (RL/2) is substituted for those COPC concentrations that are censored at the reporting limit (< RL).

During development of the SI and EE/CA work plans for Enoch Valley, Henry, and Ballard mines, IDEQ recommended that a chromium speciation study be conducted to support P4's desire to delete chromium from the list of contaminants of potential concern in soil and sediment. The agency was unwilling to see chromium deleted from the list on the basis of interim investigation results in surface water and sediment alone. Thus, after the work plans were finalized, P4 submitted a separate plan for such a study in the form of a memorandum entitled, "Chromium Speciation Sampling in Sediment, Riparian Soil, and Waste Rock Dump Soil" (B. Wright, MWH [Memorandum to R. Clegg, IDEQ] July 6, 2004). This memo and its comments has been presented here as Appendix Q.

No surface water results had yet, or since, been found to exceed either the trivalent or hexavalent chromium cold water biota standards, under either the assumption that all chromium in such water is trivalent, or the assumption that all chromium is in the far more toxic hexavalent form.

Chromium compounds tend to be found naturally in ores in their more stable trivalent state. The second most stable species of chromium is its hexavalent state; however hexavalent chromium occurs rarely in nature, and is found predominantly near man-made sources as a result of domestic and industrial emissions. Furthermore, when hexavalent chromium comes in contact with organic compounds, the result is a reduction in trivalent chromium, the more prevalent and less toxic form (Irwin, 1997). Thus, since the phosphoria formation around the mines is high in organic content, any hexavalent chromium couldn't be expected to last long, since it would quickly be reduced.

The IDEQ was willing to eliminate chromium from the surface water contaminant of potential concern list, but was unwilling to extrapolate this elimination to other media. Given that it is the hexavalent form of chromium that drives the toxicity of the element, and that USEPA has assumed 1/7th of total chromium to be hexavalent for purposes of cancer toxicity assessment (USEPA, 1998), IDEQ wanted to know the fraction of hexavalent chromium present in the solid media of interest before making a decision. P4's hypothesis was that the fraction of hexavalent chromium in these media would be much smaller than 1/7th the total because hexavalent chromium is not the common or stable form under environmental conditions—trivalent is.

In July of 2004 the chromium speciation sampling was performed. Three samples were obtained from each of the following media:

- Pond sediments;
- Stream sediments;
- Stream riparian soils; and,
- Waste rock soils (i.e., seed bed of reclaimed waste rock dumps).

As most ponds are located on waste rock, there was no need to characterize pond riparian soils separately. Sampling was biased to target locations that were expected to be highly mineralized. The fraction of hexavalent chromium is assumed to be fixed, within a range of variability, for a given medium, but P4 wanted samples that would hopefully contain high total chromium to yield the best opportunity for quantifying hexavalent chromium. Results were submitted to the IDEQ the following spring in "Chromium Speciation Study in Pond Sediment, Stream Sediment, Stream Riparian Soil, and Waste Rock Dump Soil" (B. Wright, MWH [Memorandum to R. Clegg, IDEQ] June 1, 2005).

The IDEQ forwarded USEPA comments on the chromium speciation memorandum (R. Clegg, IDEQ [e-Mail to B. Wright, MWH] July 11, 2005). The two most significant comments were requests to censor the data, and to use a consensus PEC of—rounded to two significant digits—110 mg/kg dw as a preliminary risk-based benchmark for chromium in sediments.

With regard to the first of USEPA's two comments, the data were censored and the statistical analysis of the censored data conducted. For a censored datum, one-half the reporting limit (i.e., the censoring level) was substituted in calculations. The 95th percentile of the fraction of hexavalent chromium, Cr(VI), in each of the four media of interest is presented below in Table 5-9, *Conservative Estimate of Fraction of Hexavalent Chromium in Four Solid Media*.

Table 5-9
Conservative Estimate of Fraction of Hexavalent Chromium in Four Solid Media

Medium	Percent Cr(VI), 95th Percentile
pond sediment	0.048%
stream sediment	0.11%
stream riparian soil	0.55%
surficial waste rock	1.6%

Given that the USEPAs assumption of 1/7th being hexavalent chromium is equivalent to 14%, the above data support P4's hypothesis that the fraction of Cr(VI) at their mines is indeed far less than this standard assumption—by at least an order of magnitude.

With regard to the second of USEPA's two comments, the consensus PEC of 110 mg/kg dw has been adopted as the preliminary risk-based screening benchmark for total chromium in sediment. MWH had thought that this value also assumed 14% hexavalent chromium, but apparently it does not. Internet searches have resulted in references to the value being based on total chromium or even just trivalent chromium. MWH finds this surprising, but will regard it as a total chromium benchmark unless and until specific information to the contrary is found. Table 5-1, *Enoch Valley Mine—Aquatic and Riparian Media Censored Results*, Table 5-2, *Henry Mine—Aquatic and Riparian Media Censored Results*, and Table 5-3, *Ballard Mine—Aquatic and Riparian Media Censored Results*, screens the Phase I SI data by mine against this benchmark. There are some stations that exceed the PEC, but these are limited to ponds and seeps on or near waste rock dumps. These exceedances are indicative of the presence of waste rock.

In summary, on the basis of the chromium speciation investigation findings, P4 believes chromium can be safely deleted from the contaminant of potential concern list for Enoch Valley, Henry, and Ballard mines in all media except sediment. For sediment concerns appear to be localized on or very near waste rock dumps. Exceedances of the PEC in sediment will likely prove to pose no risk to the aquatic environment, given the very low fraction of hexavalent chromium present and the relative non-toxic nature of trivalent chromium.

TASK 7: FACILITIES INVESTIGATION

No physical sample collection or laboratory analyses occurred under this task. Verification of facility locations, mine pits, waste rock dumps, stock ponds, dump seeps, and springs, occurred during 2004 field events in May, June, July, and September. In addition, in June 2004 a circum-dump reconnaissance of waste rock dumps at each mine was performed to identify and map mass wasting, potential mass wasting, and control areas along dump boundaries. A reconnaissance of Ballard Mine was performed in June 2004 to identify the different types of reclaimed areas for agronomic soil sampling. Existing maps have been compiled, verified, and revised as necessary to revise the facility map for each mine. Future map updates will occur as necessary. The following presents a history of this task.

P4 initiated the facilities investigation as outlined in the SAP. The purpose of this task is to identify those P4 facilities located at Enoch Valley, Henry, and Ballard mines, which play a role in understanding the physical extent of historical mining activities (and thus, the potential that some or all of those facilities may have to release or cause the transport of, or be affected by, constituents of potential concern). These facilities were categorized into the following groups:

- Mine pits (MMPXXX)
- Waste rock dumps (MWDXXX)
- Production wells (MPWXXX)
- Agricultural wells (MAWXXX)
- Domestic wells (MDWXXX)
- Stock ponds (MSPXXX)
- Springs (MSGXXX)
- Dump seeps (MDSXXX)
- Streams (MSTXXX)
- Reservoir (MRVXXX)

The facilities investigation began in January 2000, and has continued as a 'living' exercise. Hence, whenever new information is discovered, the facilities inventory and program maps are updated to reflect a refinement in knowledge. The history of this project is presented in timeline format below. Prior to the P4 site specific investigations, which began in 2002, the facilities inventory and mapping efforts for Enoch Valley, Henry, and Ballard mines were conducted under the umbrella of the IMA area-wide selenium investigation.

- January 2000: Aerial photographs were ordered from USGS that covered the southeast Idaho project area. These aerial photographs were taken in July—August 1992.

- March 2000: Maps arrived from the USGS, and the mapping inventory began. Aerial photo interpretation was conducted over the entire southeast project area using a stereo viewer and refined using any company specific mine maps. Using a previous inventory list, maps were created based upon facilities inventoried in 1997 by MWH and representatives from each mining company. Mine facilities included mine pits, waste rock dumps, engineered stock ponds for runoff control that contain water year round, dumps seeps and french drains, production wells, and tailings ponds. Facility boundaries were hand drawn onto existing IMA sampling maps using aerial photographs viewed by a stereoscope, and triangulation from known points.

- May 2000: Maps containing located facilities were created using AutoCAD.

- June 2000: Maps were edited with additional data located during the May 2000 sampling event.

- January 2001: MWH attended meetings with the P4 (formerly Solutia Inc.), to review the accuracy of maps for Enoch Valley, Henry, and Ballard mines.

- May 2001: Maps were used during Spring 2001 Area wide Investigation efforts. New surface water features, mine pit boundaries, dump seeps, and waste rock dumps areas were once again updated on the existing facilities maps.

- June/July 2001: Maps were divided into smaller versions so that each mine was presented as the sole mine on one map sheet. ¼ and ½ mile boundaries were established around each mine, as per the direction by the IDEQ. Within these ¼ and ½ mile IDEQ established boundaries, MWH was directed to identify specific features. These included the following:

    - Mine Waste Piles
    - Seeps/Springs/Streams (¼ mile radius)
    - Pit Lakes/Ponds/Drainage Basins (¼ mile radius)
    - Pastures/Grazing Areas (½ mile radius)
    - Apparent Wetland Areas (½ mile radius)

- Based upon conversations with IDEQ, the following information was clarified and established as sufficient effort on behalf of MWH for the Spring 2001 Area-wide Investigation:

    - Drainage basins were to be identified as surface water features (streams, ponds, seeps and springs), not as watersheds that drain into larger water bodies and encompass greater areas of landforms adjacent to mine lease boundaries.

    - Obtained information from the USFS, Bureau of Land Management (BLM), and Bureau of Indian Affairs (BIA) could sufficiently identify pastures/grazing areas. These were identified and provided to MWH in electronic format. Grazing allotments for cattle, horses, sheep, and goats were identified from records provided by the preceding agencies. The assumption that private lands don't necessarily have grazing activities was clarified by IDEQ, and were excluded as possible pasture and grazing areas.

    - Discovery of apparent wetland areas was established from the National Wetlands Inventory (NWI) website. Formal wetland delineations were not included on these maps, as IDEQ determined that the information from the NWI website was sufficient. NWI reported as having conducted these wetlands inventory in 1984 from aerial photos taken in 1980. The work was done by trained and experienced photointerpreters with the NWI.

- July 2001: Maps were submitted to P4 for further review and comments before the final deliverable to IDEQ.

- January 2002: Additional surface water features were identified for the P4 site specific investigations. Certain surface water features were reclassified for clarity and simplification. These included all standing water features such as mine pits and tailings ponds reclassified as stock ponds. The former french drain nomenclature at Henry Mine was changed to dump seep (further conversations with P4 indicated that this seep was not engineered as a french drain and that MW had incorrectly applied this nomenclature in 1997). The addition of MSGXXX stations was included in the list of facilities. This classification was used to differentiate between dump seeps, which are located on or at the terminus or waste rock piles, and those surface expressions of groundwater that were not located on waste rock dumps.

- June 2002: Surface water features were updated within the USGS hydrological layer to reflect current observed conditions, such as the confluence of No Name, Rasmussen, and Angus creeks, and the current hydrology associated with the upper tributaries of Lone Pine Creek downstream of Henry Mine's southern pit.

- May 2004: A physical survey of springs and wells was completed within a three-mile radius of Enoch Valley, Henry, and Ballard mines. Those identified facilities were mapped and presented in Attachment A, Figure of Sampling Locations, of the Phase I Site Investigation Summary Report (MWH, 2005a).

- June 2004: A circum-dump reconnaissance of Enoch Valley, Henry, and Ballard mines was conducted in support of the mass wasting investigation. No additional facilities were identified during this task.

To date, P4's mapping efforts have utilized the best available knowledge. A continual limitation of this effort centers on the large physical footprint that these historical mines have and their age since operation. In the case of surface water features, new seeps or springs may be identified only during greater-than-average precipitation periods. Thus, the maps produced by P4 and MWH represent the best and current knowledge of these three mines, refined by almost 10 years of field observations and the inclusion of any and all relevant information.

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Appendix A
Censored Historical Background Data

Appendix A: Historical Background Data—Censored

Table A1: Surface Water Historical Background Data - COPC (mg/L) - Censored Data [a]

Selenium (Unfiltered)

Station Name	Station ID	1997		1998				1999		2000		2002				2004			
		Fall	Flag	Spring	Flag	Fall	Flag	Fall	Flag	Spring	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		NS		NS		NS		<0.0010	U	<0.0010	UJ	<0.0010	U	NS	
Little Blackfoot River, above Reese Creek	MST049	NS		<0.00070	U	<0.00070	U	<0.00070	U	<0.0010	U	<0.0010	U	<0.0010	UJ	<0.0010	U	Dry	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		NS		NS		NS		<0.0010	U	NS		<0.0010	U	Dry	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	<0.00070	U	<0.00070	U	0.0018		<0.00070	U	<0.0010	U	<0.0010	U	<0.0010	UJ	<0.0010	U	Dry	
Meadow Creek, above Blackfoot Reservoir	MST235	NS		NS		NS		<0.00070	U	<0.0010	U	<0.0010	U	<0.0010	UJ	<0.0010	U	NS	
Stewart Creek, above Diamond Creek	MST236	NS		NS		NS		<0.00070	U	<0.0010	U	Dry		<0.0010	UJ	<0.0010	U	Dry	
Timber Creek, above Diamond Creek	MST237	NS		NS		NS		<0.00070	U	0.0013		<0.0010	U	<0.0010	UJ	<0.0010	U	NS	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		NS		NS		NS		<0.0010	U	NS		<0.0010	U	NS	

Cadmium (Filtered)

Station Name	Station ID	1999		2000		2002				2004			
		Fall	Flag	Spring	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		<0.00010	U	<0.00010	U	<0.00010	U	NS	
Little Blackfoot River, above Reese Creek	MST049	<0.00050	U	<0.00025	U	<0.00010	U	<0.00010	U	<0.00010	U	Dry	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		<0.00010	U	NS		<0.00020	U	Dry	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	<0.00050	U	<0.00025	U	<0.00010	U	<0.00010	U	<0.00010	U	Dry	
Meadow Creek, above Blackfoot Reservoir	MST235	<0.00050	U	<0.00025	U	<0.00010	U	<0.0011	U	<0.00020	U	NS	
Stewart Creek, above Diamond Creek	MST236	<0.00050	U	<0.00025	U	Dry		<0.00010	U	<0.00010	U	Dry	
Timber Creek, above Diamond Creek	MST237	<0.00050	U	<0.00025	U	<0.00010	U	<0.00050	U	<0.00010	U	NS	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		<0.00010	U	NS		<0.00010	U	NS	

Chromium (Filtered)

Station Name	Station ID	1999		2000		2002				2004			
		Fall	Flag	Spring	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		<0.010	U	NA		NA		NS	
Little Blackfoot River, above Reese Creek	MST049	NA		NA		<0.010	U	NA		NA		Dry	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		<0.010	U	NS		<0.00020	U	Dry	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA		NA		<0.010	U	NA		NA		Dry	
Meadow Creek, above Blackfoot Reservoir	MST235	NA		NA		<0.010	U	NA		NA		NS	
Stewart Creek, above Diamond Creek	MST236	NA		NA		Dry		NA		0.00030		Dry	
Timber Creek, above Diamond Creek	MST237	NA		NA		<0.010	U	NA		NA		NS	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		<0.010	U	NS		NA		NS	

Nickel (Filtered)

Station Name	Station ID	1999		2000		2002				2004			
		Fall	Flag	Spring	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		<0.0035	UJ	<0.028	U	<0.0050	U	NS	
Little Blackfoot River, above Reese Creek	MST049	NA		NA		<0.0035	UJ	<0.028	U	<0.0050	U	Dry	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		<0.0035	UJ	NS		<0.0050	U	Dry	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA		NA		<0.0035	UJ	<0.028	U	<0.0050	U	Dry	
Meadow Creek, above Blackfoot Reservoir	MST235	NA		NA		<0.0035	UJ	<0.028	U	<0.0050	U	NS	
Stewart Creek, above Diamond Creek	MST236	NA		NA		Dry		<0.028	U	<0.00020	U	Dry	
Timber Creek, above Diamond Creek	MST237	NA		NA		<0.0035	UJ	<0.028	U	<0.0050	U	NS	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		<0.0035	UJ	NS		<0.0050	U	NS	

Table A1: Surface Water Historical Background Data - COPC (mg/L) - Censored Data (Continued) [a]

Station Name	Station ID	Vanadium (Filtered)											
		1999		2000		2002				2004			
		Fall	Flag	Spring	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		<0.0050	U	<0.0050	U	0.0023		NS	
Little Blackfoot River, above Reese Creek	MST049	NA		NA		<0.0050	U	<0.0050	U	0.00065		Dry	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		0.011		NS		0.0062		Dry	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA		NA		<0.0050	U	<0.0050	U	<0.00048	U	Dry	
Meadow Creek, above Blackfoot Reservoir	MST235	NA		NA		<0.0050	U	<0.0050	U	0.0022		NS	
Stewart Creek, above Diamond Creek	MST236	NA		NA		Dry		<0.0050	U	<0.00048	U	Dry	
Timber Creek, above Diamond Creek	MST237	NA		NA		<0.0050	U	0.00032		<0.00048	U	NS	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		0.0050		NS		0.00055		NS	

Station Name	Station ID	Zinc (Filtered)											
		1999		2000		2002				2004			
		Fall	Flag	Spring	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		<0.015	U	<0.075	U	<0.0040	U	NS	
Little Blackfoot River, above Reese Creek	MST049	NA		NA		<0.0020	U	<0.075	U	<0.0020	U	Dry	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		<0.0020	U	NS		<0.0040	U	Dry	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA		NA		<0.0020	U	<0.075	U	<0.0020	U	Dry	
Meadow Creek, above Blackfoot Reservoir	MST235	NA		NA		<0.0020	U	<0.075	U	<0.0040	U	NS	
Stewart Creek, above Diamond Creek	MST236	NA		NA		Dry		<0.075	U	0.014		Dry	
Timber Creek, above Diamond Creek	MST237	NA		NA		<0.015	U	<0.075	U	0.014		NS	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		<0.015	U	NS		<0.0027	U	NS	

Notes:
All data has been censored at the reporting limit. Laboratory and field duplicates have been averaged.
[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).
Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses.
Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure, or for below the detection limit results for 1997-2000 data.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration.
The result is an estimate and may be inaccurate or imprecise.
COPC - Constituents of Potential Concern.
RL - Reporting Limit.
NA - Not Analyzed.

Table A2: Sediment Historical Background Data - COPC (mg/kg dry weight) - Censored Data[a]

Station Name	Station ID	Selenium										Cadmium									
		1998		1999		2002				2004		1998		1999		2002				2004	
		Fall	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Spring	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		<1.4	UJ		UR	<0.50	UJ	NS		NS		0.48	J	0.70		0.39	J
Little Blackfoot River, above Reese Creek	MST049	0.88		1.3		<1.4	UJ	0.90	J	<0.50	UJ	3.7		3.6		1.5	J	1.2		1.2	J
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		<1.4	UJ	NS		<0.50	UJ	NS		NS		2.6	J	NS		1.8	J
Caldwell Creek, below Phosphoria Formation outcrop	MST101	1.1		1.0		<1.4	UJ		UR	0.70	J	4.3		4.4		1.0	J	1.2		1.8	J
Meadow Creek, above Blackfoot Reservoir	MST235	NS		0.13		<1.4	UJ		UR	<0.50	UJ	NS		0.49		0.60	J	0.80		0.22	J
Stewart Creek, above Diamond Creek	MST236	NS		1.1		NS		0.60	J	<0.50	UJ	NS		4.2		NS		3.2		3.1	J
Timber Creek, above Diamond Creek	MST237	NS		1.3		<1.4	UJ	0.57	J	<0.50	UJ	NS		4.4		0.87	J	0.58		0.90	J
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		<1.4	UJ	NS		<0.50	UJ	NS		NS		1.5	J	NS		0.78	J

Station Name	Station ID	Chromium										Nickel									
		1998		1999		2002				2004		1998		1999		2002				2004	
		Fall	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Spring	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		11		17		14		NS		NS		6.6	J	11		9.1	
Little Blackfoot River, above Reese Creek	MST049	NA		NA		26		19		26		50		NA		18	J	12		16	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		21		NS		28		NS		NS		19	J	NS		20	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA		NA		18		24		22		51		NA		21	J	25		21	
Meadow Creek, above Blackfoot Reservoir	MST235	NS		NA		18		18		<13	U	NS		NA		9.6	J	12		<6.3	U
Stewart Creek, above Diamond Creek	MST236	NS		NA		NS		32		32		NS		NA		NS		27		24	
Timber Creek, above Diamond Creek	MST237	NS		NA		19		20		20		NS		NA		20	J	22		18	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		22		NS		20		NS		NS		15	J	NS		13	

Station Name	Station ID	Vanadium										Zinc									
		1998		1999		2002				2004		1998		1999		2002				2004	
		Fall	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Spring	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		11		18		16		NS		NS		21		<67	U	26	J
Little Blackfoot River, above Reese Creek	MST049	47		NA		30		21		29		70		NA		95		69		76	J
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		32		NS		38		NS		NS		120		NS		93	J
Caldwell Creek, below Phosphoria Formation outcrop	MST101	40		NA		21		21		26		117		NA		90		100		90	J
Meadow Creek, above Blackfoot Reservoir	MST235	NS		NA		18		17		11		NS		NA		37		<67	U	18	J
Stewart Creek, above Diamond Creek	MST236	NS		NA		NS		35		37		NS		NA		NS		110		120	J
Timber Creek, above Diamond Creek	MST237	NS		NA		21		23		26		NS		NA		80		78		66	J
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		22		NS		23		NS		NS		83		NS		75	J

Notes:

All data has been censored at the reporting limit. Laboratory and field duplicates have been averaged.

[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).

Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure, or for below the detection limit results for 1997-2000 data.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

COPC - Constituents of Potential Concern.

RL - Reporting Limit.

NA - Not Analyzed.

NS - Not Sampled.

Table A3: Benthic Macroinvertebrates Historical Background Data - COPC (mg/kg dry weight) - Censored Data [a]														
Station Name	Station ID	Selenium						Cadmium						
		1999		2000		2004		1999		2000		2004		
		Fall	Flag	Spring	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Spring	Flag	
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		NS		NS		NS		NS		
Little Blackfoot River, above Reese Creek	MST049	NS		NS		3.3	J	NS		NS		NA		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		<8.3	UJ	NS		NS		NA		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS		NS		<2.9	UJ	NS		NS		NA		
Meadow Creek, above Blackfoot Reservoir	MST235	NS		NS		<12	UJ	NS		NS		NA		
Stewart Creek, above Diamond Creek	MST236	0.50		4.1		<4.2	UJ	3.8		4.1		NA		
Timber Creek, above Diamond Creek	MST237	2.0		2.6		<4.0	UJ	4.0		NA		NA		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		<1.3	UJ	NS		NS		NA		

Notes:
All data has been censored at the reporting limit. Laboratory and field duplicates have been averaged.
[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).
Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).
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(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration.
The result is an estimate and may be inaccurate or imprecise.
COPC - Constituents of Potential Concern.
RL - Reporting Limit.
NA - Not Analyzed.
NS - Not Sampled.

Table A4: Fish Historical Background Data - COPC (mg/kg dry weight) - Censored Data[a]																			
		Salmonids				Forage Fish													
		Selenium		Cadmium		Selenium				Cadmium				Nickel		Vanadium		Zinc	
Station Name	Station ID	1999				1999		2004		1999		2004		2004		2004		2004	
		Fall	Flag	Fall	Flag	Fall	Flag	Spring	Flag	Fall	Flag	Spring	Flag	Spring	Flag	Spring	Flag	Spring	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		NS		3.0		NS		0.089		1.8		0.81		160	
Little Blackfoot River, above Reese Creek	MST049	NS		NS		NS		NS		NS		NS		NS		NS		NS	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		NS		NS		NS		NS		NS		NS		NS	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS		NS		NS		NS		NS		NS		NS		NS		NS	
Meadow Creek, above Blackfoot Reservoir	MST235	NS		NS		NS		2.7		NS		<0.081	U	4.0		0.57		130	
Stewart Creek, above Diamond Creek	MST236	2.8		0.39		5.4		NS		0.79		NS		NS		NS		NS	
Timber Creek, above Diamond Creek	MST237	4.0		0.33		7.6		3.3		2.8		0.087		<0.19	U	0.67		78	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		NS		<2.4	U	NS		<0.24	U	24		0.95		180	

Notes:
All data has been censored at the reporting limit. Laboratory and field duplicates have been averaged.
[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).
Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).
Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure, or for below the detection limit results for 1997-2000 data.
Data qualifier definitions are:
(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.
(J) - The result is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration.
The result is an estimate and may be inaccurate or imprecise.
COPC - Constituents of Potential Concern.
RL - Reporting Limit.
NA - Not Analyzed.
NS - Not Sampled.

Table A5: Riparian Soil Historical Background Data - COPC (mg/kg dry weight) - Censored Data [a]

Station Name	Station ID	Selenium				Cadmium				Chromium				Copper				Molybdenum				Nickel				Vanadium				Zinc			
		2001		2004		2001		2004		2001		2004		2001		2004		2001		2004		2001		2004		2001		2004		2001		2004	
		Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		<0.50	U	NS		0.53	J	NS		14	J	NS		5.3	J	NS		<1.4	U	NS		<8.4	U	NS		<20	U	NS		24	
Little Blackfoot River, above Reese Creek	MST049	1.2		<0.50	U	R		1.4	J	56	J	25	J	18	J	15	J	NA		<1.4	U	16	J	16		55	J	29		95	J	77	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		0.50		NS		2.7	J	NS		23	J	NS		21	J	NS		<1.4	U	NS		15		NS		30		NS		110	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS		0.50		NS		1.8	J	NS		26	J	NS		19	J	NS		<1.4	U	NS		21		NS		33		NS		99	
Meadow Creek, above Blackfoot Reservoir	MST235	0.51		<0.50	U	R		0.60	J	41	J	22	J	11	J	11	J	NA		<1.4	U	18	J	10		37	J	23		57	J	42	
Stewart Creek, above Diamond Creek	MST236	NS		0.70		NS		4.4	J	NS		43	J	NS		19	J	NS		1.7	J	NS		27		NS		52		NS		160	
Timber Creek, above Diamond Creek	MST237	1.5		0.70		R		1.4	J	40	J	27	J	19	J	16	J	NA		<1.4	U	24	J	18		50	J	35		99	J	91	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		<0.50	U	NS		1.2	J	NS		21	J	NS		12	J	NS		<1.4	U	NS		13		NS		25		NS		60	

Notes:

All data has been censored at the reporting limit. Laboratory and field duplicates have been averaged.

[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).

Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).

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Data qualifier definitions are:

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(R) - The data are unusable.

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COPC - Constituents of Potential Concern.

RL - Reporting Limit.

NA - Not Analyzed.

NS - Not Sampled.

Table A6: Riparian Vegetation Historical Background Data - COPC (mg/kg dry weight) - Censored Data [a]

Station Name	Station ID	Selenium						Cadmium						Copper						Molybdenum					
		1999		2001		2004		1999		2001		2004		1999		2001		2004		1999		2001		2004	
		Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		<0.50	U	NS		NS		0.080		NS		NS		<9.3	U	NS		NS		<0.78	U
Little Blackfoot River, above Reese Creek	MST049	NS		0.20		<0.50	U	NS		0.73		0.14		NS		3.7	J	<9.3	U	NS		0.84		2.6	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		<0.50	U	NS		NS		0.35		NS		NS		<9.3	U	NS		NS		1.6	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS		NS		0.80		NS		NS		0.60		NS		NS		<9.3	U	NS		NS		2.4	
Meadow Creek, above Blackfoot Reservoir	MST235	NS		0.18		<0.50	U	NS		0.089		0.11		NS		4.3	J	<9.3	U	NS		0.89		<0.78	U
Stewart Creek, above Diamond Creek	MST236	0.90		NS		<0.50	U	0.78		NS		0.90		NA		NS		<9.3	U	NA		NS		0.94	
Timber Creek, above Diamond Creek	MST237	0.094		0.25		<0.50	U	0.22		0.28		0.34		NA		4.3	J	<9.3	U	NA		0.71		<0.78	U
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		<0.50	U	NS		NS		0.12		NS		NS		<9.3	U	NS		NS		0.91	

Station Name	Station ID	Nickel						Vanadium						Zinc					
		1999		2001		2004		1999		2001		2004		1999		2001		2004	
		Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag	Fall	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		NA		NS		NS		NA		NS		NS		38	
Little Blackfoot River, above Reese Creek	MST049	NS		0.88		NA		NS		2.0		NA		NS		40	J	28	
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		NA		NS		NS		NA		NS		NS		27	
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS		NS		NA		NS		NS		NA		NS		NS		64	
Meadow Creek, above Blackfoot Reservoir	MST235	NS		0.49		NA		NS		0.76		NA		NS		23	J	12	
Stewart Creek, above Diamond Creek	MST236	NA		NS		NA		NA		NS		NA		NA		NS		52	
Timber Creek, above Diamond Creek	MST237	NA		0.48		NA		NA		0.52		NA		NA		29	J	28	
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		NA		NS		NS		NA		NS		NS		23	

Notes:
All data has been censored at the reporting limit. Laboratory and field duplicates have been averaged.
[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).
Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).
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COPC - Constituents of Potential Concern.
RL - Reporting Limit.
NA - Not Analyzed.
NS - Not Sampled.

Table A7: Upland Historical Background Data - COPC (mg/kg dry weight) - Censored Data [a, b]													
		Upland Soil						Upland Vegetation					
		Selenium						Selenium					
Station Name	Station ID	1998		2000		2001		1998		2000		2001	
		Summer	Flag	Summer	Flag	Summer	Flag	Summer	Flag	Summer	Flag	Summer	Flag
Caldwell Creek Outcrop Quadrant 1	BB002-1	0.78		NS		NS		0.16		NS		NS	
Caldwell Creek Outcrop Quadrant 2	BB002-2	1.4		NS		NS		0.11		NS		NS	
Caldwell Creek Outcrop Quadrant 3	BB002-3	1.4		NS		NS		0.020		NS		NS	
Caldwell Creek Outcrop Quadrant 4	BB002-4	1.1		NS		NS		0.040		NS		NS	
Caldwell Creek Outcrop Quadrant 5	BB002-5	0.84		NS		NS		0.14		NS		NS	
Background Phosphoria Outcrop, SE of Conda Mine	BB004-1	NS		NS		0.41		NS		NS		0.052	
Background Phosphoria Outcrop, SE of Conda Mine	BB004-2	NS		NS		0.44		NS		NS		0.099	
Background Phosphoria Outcrop, SE of Conda Mine	BB004-3	NS		NS		0.47		NS		NS		0.12	
Background Phosphoria Outcrop, near N. End of Slug Valley	BB005-1	NS		NS		<0.040	U	NS		NS		0.10	
Background Phosphoria Outcrop, near N. End of Slug Valley	BB005-2	NS		NS		0.73		NS		NS		0.11	
Background Phosphoria Outcrop, near N. End of Slug Valley	BB005-3	NS		NS		0.85		NS		NS		0.11	
Background Phosphoria Outcrop, near Stewart Creek drainage	BB006-1	NS		NS		0.60		NS		NS		0.12	
Background Phosphoria Outcrop, near Stewart Creek drainage	BB006-2	NS		NS		0.61		NS		NS		0.20	
Background Phosphoria Outcrop, near Stewart Creek drainage	BB006-3	NS		NS		0.78		NS		NS		0.21	
Background Phosphoria Outcrop, near Diamond Creek drainage	BB007-1	NS		NS		2.5		NS		NS		0.32	
Background Phosphoria Outcrop, near Diamond Creek drainage	BB007-2	NS		NS		2.8		NS		NS		0.38	
Background Phosphoria Outcrop, near Diamond Creek drainage	BB007-3	NS		NS		3.3		NS		NS		0.42	
Enoch Valley Mine Topsoil Stockpile 1	TOST01	NS		3.1		NS		NS		1.2		NS	
Enoch Valley Mine Topsoil Stockpile 2	TOST02	NS		1.2		NS		NS		0.094		NS	
Enoch Valley Mine Topsoil Stockpile 3	TOST03	NS		1.2		NS		NS		0.15		NS	
South Rasmussen Background 1	SRBG01	NS		1.2		NS		NS		0.15		NS	
South Rasmussen Background 2	SRBG02	NS		3.6		NS		NS		0.57		NS	
South Rasmussen Background 3	SRBG03	NS		3.3		NS		NS		0.13		NS	
South Rasmussen Background 4	SRBG04	NS		2.4		NS		NS		0.23		NS	
South Rasmussen Background 5	SRBG05	NS		2.3		NS		NS		0.22		NS	
South Rasmussen Background 6	SRBG06	NS		2.4		NS		NS		0.16		NS	

Notes:

All data has been censored at the reporting limit. Laboratory and field duplicates have been averaged.

[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).

b Additional analytes are available for this historical media, however, on selenium is relevant for the SI-ES.

Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).

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The result is an estimate and may be inaccurate or imprecise.

COPC - Constituents of Potential Concern.

RL - Reporting Limit.

NA - Not Analyzed.

NS - Not Sampled.

Appendix B
Uncensored Historical Background Data

Appendix B: Historical Background Data—Censored

Table B1: Surface Water Historical Background Data - COPC (mg/L) - Uncensored Data[a]

Selenium (Unfiltered)

Station Name	Station ID	1997			1998						1999			2000			2002						2004					
		Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			NS			NS			NS			0.00020	0.0010	U	-0.0013	0.0010	UJ	-0.00025	0.0010	U	NS		
Little Blackfoot River, above Reese Creek	MST049	NS			-0.0011	0.00070	U	0.000033	0.00070	U	0.00020	0.00070	U	-0.00023	0.0010	U	-0.00017	0.0010	U	0.00037	0.0010	UJ	-0.00039	0.0010	U	Dry		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			NS			NS			NS			0.00070	0.0010	U	NS			0.00091	0.0010	U	Dry		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	0.00054	0.00070	U	-0.00040	0.00070	U	0.0018			-0.00017	0.00070	U	0.000017	0.0010	U	-0.00020	0.0010	U	-0.00077	0.0010	UJ	-0.00042	0.0010	U	Dry		
Meadow Creek, above Blackfoot Reservoir	MST235	NS			NS			NS			0.00080	0.00070	U	0.00049	0.0010	U	0	0.0010	U	-0.0012	0.0010	UJ	-0.00083	0.0010	U	NS		
Stewart Creek, above Diamond Creek	MST236	NS			NS			NS			-0.00064	0.00070	U	0.00040	0.0010	U	Dry			-0.0018	0.0010	UJ	-0.00074	0.0010	U	Dry		
Timber Creek, above Diamond Creek	MST237	NS			NS			NS			-0.00058	0.00070	U	0.0013			-0.00013	0.0010	U	-0.0015	0.0010	UJ	-0.0089	0.0010	U	NS		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			NS			NS			NS			0.00030	0.0010	U	NS			-0.00069	0.0010	U	NS		

Cadmium (Filtered)

Station Name	Station ID	1999			2000			2002						2004					
		Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			0.000040	0.00010	U	0.000013	0.00010	U	-0.000010	0.00010	U	NS		
Little Blackfoot River, above Reese Creek	MST049	-0.00031	0.00050	U	-0.0000020	0.00025	U	0.000020	0.00010	U	0.000050	0.00010	U	0.000010	0.00010	U	Dry		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			0.000060	0.00010	U	NS			0.000070	0.00020	U	Dry		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	-0.00046	0.00050	U	0.00000060	0.00025	U	0	0.00010	U	-0.000020	0.00010	U	0	0.00010	U	Dry		
Meadow Creek, above Blackfoot Reservoir	MST235	-0.00059	0.00050	U	0.000021	0.00025	U	0.000010	0.00010	U	0.00010	0.0011	U	-0.000010	0.00020	U	NS		
Stewart Creek, above Diamond Creek	MST236	-0.00002	0.00050	U	-0.0000067	0.00025	U	Dry			-0.000020	0.00010	U	0.000010	0.00010	U	Dry		
Timber Creek, above Diamond Creek	MST237	0.000088	0.00050	U	0.0000017	0.00025	U	0.000050	0.00010	U	0.00011	0.00050	U	0.000020	0.00010	U	NS		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			0.000010	0.00010	U	NS			0.0000033	0.00010	U	NS		

Chromium (Filtered)

Station Name	Station ID	1999			2000			2002						2004					
		Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			0.0010	0.010	U	NA			NA			NS		
Little Blackfoot River, above Reese Creek	MST049	NA			NA			-0.0040	0.010	U	NA			NA			Dry		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			0.0020	0.010	U	NS			0.00016	0.00020	U	Dry		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA			NA			0.0020	0.010	U	NA			NA			Dry		
Meadow Creek, above Blackfoot Reservoir	MST235	NA			NA			-0.0010	0.010	U	NA			NA			NS		
Stewart Creek, above Diamond Creek	MST236	NA			NA			Dry			NA			0.00030			Dry		
Timber Creek, above Diamond Creek	MST237	NA			NA			-0.0020	0.010	U	NA			NA			NS		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			-0.0010	0.010	U	NS			NA			NS		

Nickel (Filtered)

Station Name	Station ID	1999			2000			2002						2004					
		Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			0.0014	0.0035	UJ	0.0014	0.028	U	0.00080	0.0050	U	NS		
Little Blackfoot River, above Reese Creek	MST049	NA			NA			0.0014	0.0035	UJ	0.0022	0.028	U	0.00050	0.0050	U	Dry		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			0.0016	0.0035	UJ	NS			0.00080	0.0050	U	Dry		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA			NA			0.0011	0.0035	UJ	0.0052	0.028	U	0.00060	0.0050	U	Dry		
Meadow Creek, above Blackfoot Reservoir	MST235	NA			NA			0.0008	0.0035	UJ	0.0010	0.028	U	0.00050	0.0050	U	NS		
Stewart Creek, above Diamond Creek	MST236	NA			NA			Dry			0.0030	0.028	U	0.00015	0.00020	U	Dry		
Timber Creek, above Diamond Creek	MST237	NA			NA			0.0015	0.0035	UJ	0.0031	0.028	U	0.00020	0.0050	U	NS		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			0.0012	0.0035	UJ	NS			0.00080	0.0050	U	NS		

Table B1: Surface Water Historical Background Data - COPC (mg/L) - Uncensored Data (Continued) [a]																			
Station Name	Station ID	Vanadium (Filtered)																	
		1999			2000			2002						2004					
		Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			0.0020	0.0050	U	0.0011	0.0050	U	0.0023			NS		
Little Blackfoot River, above Reese Creek	MST049	NA			NA			0	0.0050	U	0.00096	0.0050	U	0.00065			Dry		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			0.0110			NS			0.0062			Dry		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA			NA			-0.0010	0.0050	U	0.00058	0.0050	U	0.00042	0.00048	U	Dry		
Meadow Creek, above Blackfoot Reservoir	MST235	NA			NA			0.0040	0.0050	U	0.0016	0.0050	U	0.0022			NS		
Stewart Creek, above Diamond Creek	MST236	NA			NA			Dry			0.00027	0.0050	U	0.00023	0.00048	U	Dry		
Timber Creek, above Diamond Creek	MST237	NA			NA			-0.00017	0.0050	U	0.00032			0.00034	0.00048	U	NS		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			0.0050			NS			0.00055			NS		
Station Name	Station ID	Zinc (Filtered)																	
		1999			2000			2002						2004					
		Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			0.0040	0.015	U	0.010	0.075	U	0.0010	0.0040	U	NS		
Little Blackfoot River, above Reese Creek	MST049	NA			NA			0.00086	0.0020	U	0.010	0.075	U	0.00051	0.0020	U	Dry		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			0.0011	0.0020	U	NS			-0.00023	0.0040	U	Dry		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA			NA			0.0010	0.0020	U	0.015	0.075	U	0.00042	0.0020	U	Dry		
Meadow Creek, above Blackfoot Reservoir	MST235	NA			NA			0.0012	0.0020	U	0.015	0.075	U	0.00012	0.0040	U	NS		
Stewart Creek, above Diamond Creek	MST236	NA			NA			Dry			0.0070	0.075	U	0.014			Dry		
Timber Creek, above Diamond Creek	MST237	NA			NA			0.0030	0.015	U	0.012	0.075	U	0.014			NS		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			0.0050	0.015	U	NS			0.00073	0.0027	U	NS		

Notes:

The data has not been censored at the reporting limit; the instrument reading for each result below the reporting limit has been provided. Laboratory and field duplicates have been averaged.

[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).

Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).

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Data qualifier definitions are:

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(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

COPC - Constituents of Potential Concern.

RL - Reporting Limit.

NA - Not Analyzed.

NS - Not Sampled.

Table B2: Sediment Historical Background Data - COPC (mg/kg dry weight) - Uncensored Data[a]

Selenium

Station Name	Station ID	1998			1999			2002						2004		
		Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			0.20	1.4	UJ			UR	-0.071	0.50	UJ
Little Blackfoot River, above Reese Creek	MST049	0.88			1.3			0.83	1.4	UJ	0.90		J	0.43	0.50	UJ
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			0.40	1.4	UJ	NS			0.072	0.50	UJ
Caldwell Creek, below Phosphoria Formation outcrop	MST101	1.1			1.0			0.60	1.4	UJ			UR	0.70		J
Meadow Creek, above Blackfoot Reservoir	MST235	NS			0.13			0.70	1.4	UJ			UR	0.11	0.50	UJ
Stewart Creek, above Diamond Creek	MST236	NS			1.1			NS			0.60		J	0.27	0.50	UJ
Timber Creek, above Diamond Creek	MST237	NS			1.3			1.0	1.4	UJ	0.57		J	0.11	0.50	UJ
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			0.40	1.4	UJ	NS			0.16	0.50	UJ

Cadmium

Station Name	Station ID	1998			1999			2002						2004		
		Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			0.48		J	0.70			0.39		J
Little Blackfoot River, above Reese Creek	MST049	3.7			3.6			1.5		J	1.2			1.2		J
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			2.6		J	NS			1.8		J
Caldwell Creek, below Phosphoria Formation outcrop	MST101	4.3			4.4			1.0		J	1.2			1.8		J
Meadow Creek, above Blackfoot Reservoir	MST235	NS			0.49			0.60		J	0.80			0.22		J
Stewart Creek, above Diamond Creek	MST236	NS			4.2			NS			3.2			3.1		J
Timber Creek, above Diamond Creek	MST237	NS			4.4			0.87		J	0.58			0.90		J
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			1.5		J	NS			0.78		J

Chromium

Station Name	Station ID	1998			1999			2002						2004		
		Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			11			17			14		
Little Blackfoot River, above Reese Creek	MST049	NA			NA			26			19			26		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			21			NS			28		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NA			NA			18			24			22		
Meadow Creek, above Blackfoot Reservoir	MST235	NS			NA			18			18			12	13	U
Stewart Creek, above Diamond Creek	MST236	NS			NA			NS			32			32		
Timber Creek, above Diamond Creek	MST237	NS			NA			19			20			20		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			22			NS			20		

Nickel

Station Name	Station ID	1998			1999			2002						2004		
		Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			6.6		J	11			9.1		
Little Blackfoot River, above Reese Creek	MST049	50			NA			18		J	12			16		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			19		J	NS			20		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	51			NA			21		J	25			21		
Meadow Creek, above Blackfoot Reservoir	MST235	NS			NA			9.6		J	12			5.8	6.3	U
Stewart Creek, above Diamond Creek	MST236	NS			NA			NS			27			24		
Timber Creek, above Diamond Creek	MST237	NS			NA			20		J	22			18		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			15		J	NS			13		

Vanadium

Station Name	Station ID	1998			1999			2002						2004		
		Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			11			18			16		
Little Blackfoot River, above Reese Creek	MST049	47			NA			30			21			29		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			32			NS			38		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	40			NA			21			21			26		
Meadow Creek, above Blackfoot Reservoir	MST235	NS			NA			18			17			11		
Stewart Creek, above Diamond Creek	MST236	NS			NA			NS			35			37		
Timber Creek, above Diamond Creek	MST237	NS			NA			21			23			26		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			22			NS			23		

Zinc

Station Name	Station ID	1998			1999			2002						2004		
		Fall	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			21			41	67	U	26		J
Little Blackfoot River, above Reese Creek	MST049	70			NA			95			69			76		J
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			120			NS			93		J
Caldwell Creek, below Phosphoria Formation outcrop	MST101	117			NA			90			100			90		J
Meadow Creek, above Blackfoot Reservoir	MST235	NS			NA			37			38	67	U	18		J
Stewart Creek, above Diamond Creek	MST236	NS			NA			NS			110			120		J
Timber Creek, above Diamond Creek	MST237	NS			NA			80			78			66		J
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			83			NS			75		J

Notes:

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[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).

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(J) - The result is an estimated quantity.

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(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration. The result is an estimate and may be inaccurate or imprecise.

COPC - Constituents of Potential Concern.

RL - Reporting Limit.

NA - Not Analyzed.

NS - Not Sampled.

Table B3: Benthic Macroinvertebrates Historical Background Data - COPC (mg/kg dry weight) - Uncensored Data [a]

Station Name	Station ID	Selenium									Cadmium								
		1999			2000			2004			1999			2000			2004		
		Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			NS			NS			NS			NS			NS		
Little Blackfoot River, above Reese Creek	MST049	NS			NS			3.3		J	NS			NS			NA		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			NS			-6.7	8.3	UJ	NS			NS			NA		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS			NS			1.3	2.9	UJ	NS			NS			NA		
Meadow Creek, above Blackfoot Reservoir	MST235	NS			NS			-9.0	23	UJ	NS			NS			NA		
Stewart Creek, above Diamond Creek	MST236	0.50			4.1			-4.0	4.2	UJ	3.8			4.1			NA		
Timber Creek, above Diamond Creek	MST237	2.0			2.6			-2.2	4.0	UJ	4.0			NA			NA		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			NS			-0.51	1.3	UJ	NS			NS			NA		

Notes:

The data has not been censored at the reporting limit; the instrument reading for each result below the reporting limit has been provided. Laboratory and field duplicates have been averaged.

[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).

Data collected subsequent to 2000 have been validated in accordance with MWH SOP-NW-18.1 and USEPA Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses. Data collected from 1997-2000 have been validated in accordance with the respective investigation's sampling and analysis plan; only results below the detection limit have been qualified as undetected (U).

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure, or for below the detection limit results for 1997-2000 data.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is the sample reporting limit.

(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration.
The result is an estimate and may be inaccurate or imprecise.

COPC - Constituents of Potential Concern.

RL - Reporting Limit.

NA - Not Analyzed.

NS - Not Sampled.

Table B4: Fish Historical Background Data - COPC (mg/kg dry weight) - Uncensored Data [a]																												
Station Name	Station ID	Salmonids				Forage Fish																						
		Selenium		Cadmium		Selenium						Cadmium						Nickel			Vanadium			Zinc		
		1999				1999			2004			1999			2004			2004			2004			2004		
		Fall	Flag	Fall	Flag	Fall	RL	Flag	Spring	RL	Flag	Fall	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag	Spring	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS		NS		NS			3.0			NS			0.089			1.8			0.81			160		
Little Blackfoot River, above Reese Creek	MST049	NS		NS		NS			NS			NS			NS			NS			NS			NS		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS		NS		NS			NS			NS			NS			NS			NS			NS		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS		NS		NS			NS			NS			NS			NS			NS			NS		
Meadow Creek, above Blackfoot Reservoir	MST235	NS		NS		NS			2.7			NS			0.068	0.081	U	4.0			0.57			130		
Stewart Creek, above Diamond Creek	MST236	2.8		0.39		5.4			NS			0.79			NS			NS			NS			NS		
Timber Creek, above Diamond Creek	MST237	4.0		0.33		7.6			3.3			2.8			0.087			-0.084	0.19	U	0.67			78		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS		NS		NS			-0.12	2.4	U	NS			0.16	0.24	U	24			0.95			180		

Notes:

The data has not been censored at the reporting limit; the instrument reading for each result below the reporting limit has been provided. Laboratory and field duplicates have been averaged.

[a] Reported results are unadjusted data produced under the following investigations, respectively: Fall 1997 Surface Water Survey (Idaho Mining Association), 1998-2000 Regional Investigation (Idaho Mining Association), 2002 Interim Surface Water and Sediment Investigation (P4 Site Investigations), 2004 Comprehensive Site Investigation (P4 Site Investigations).

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Data qualifier definitions are:

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(J) - The result is an estimated quantity.

(R) - The data are unusable.

(UJ) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 times the highest blank concentration.
The result is an estimate and may be inaccurate or imprecise.

COPC - Constituents of Potential Concern.

RL - Reporting Limit.

NA - Not Analyzed.

NS - Not Sampled.

Table B5: Riparian Soil Historical Background Data - COPC (mg/kg dry weight) - Uncensored Data [a]

Station Name	Station ID	Selenium						Cadmium						Chromium						Copper						Molybdenum					
		2001			2004			2001			2004			2001			2004			2001			2004			2001			2004		
		Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			-0.19	0.50	U	NS			0.53		J	NS			14		J	NS			5		J	NS			0.15	1.4	U
Little Blackfoot River, above Reese Creek	MST049	1.2			0.34	0.50	U	R			1.4		J	56		J	25		J	18		J	15		J	NA			0.45	1.4	U
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			0.50			NS			2.7		J	NS			23		J	NS			21		J	NS			0.58	1.4	U
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS			0.50			NS			1.8		J	NS			26		J	NS			19		J	NS			0.47	1.4	U
Meadow Creek, above Blackfoot Reservoir	MST235	0.51			-0.13	0.50	U	R			0.60		J	41		J	22		J	11		J	11		J	NA			0.17	1.4	U
Stewart Creek, above Diamond Creek	MST236	NS			0.70			NS			4.4		J	NS			43		J	NS			19		J	NS			1.7	1.4	J
Timber Creek, above Diamond Creek	MST237	1.5			0.70			R			1.4		J	40		J	27		J	19		J	16		J	NA			0.40	1.4	U
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			-0.020	0.50	U	NS			1.2		J	NS			21		J	NS			12		J	NS			0.43	1.4	U

Station Name	Station ID	Nickel						Vanadium						Zinc					
		2001			2004			2001			2004			2001			2004		
		Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	MRV017	NS			7.8	8.4	U	NS			16	20	U	NS			24		
Little Blackfoot River, above Reese Creek	MST049	16		J	16			55		J	29			95		J	77		
North Fork Wooley Valley Creek, above Ballard Mine	MST093	NS			15			NS			30			NS			110		
Caldwell Creek, below Phosphoria Formation outcrop	MST101	NS			21			NS			33			NS			99		
Meadow Creek, above Blackfoot Reservoir	MST235	18		J	10			37		J	23			57		J	42		
Stewart Creek, above Diamond Creek	MST236	NS			27			NS			52			NS			160		
Timber Creek, above Diamond Creek	MST237	24		J	18			50		J	35			99		J	91		
Little Blackfoot River, upstream of Henry cutoff road	MST254	NS			13			NS			25			NS			60		

Notes:

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RL - Reporting Limit.

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NS - Not Sampled.

Table B6: Riparian Vegetation Historical Background Data - COPC (mg/kg dry weight) - Uncensored Data[a]

Station Name	Stati	Selenium									Cadmium								
		1999			2001			2004			1999			2001			2004		
		Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	IRV01	NS			NS			-0.36	0.50	U	NS			NS			####		
Little Blackfoot River, above Reese Creek	IST04	NS			0.20			-0.32	0.50	U	NS			0.73			0.14		
North Fork Wooley Valley Creek, above Ballard Mine	IST09	NS			NS			0.23	0.50	U	NS			NS			0.35		
Caldwell Creek, below Phosphoria Formation outcrop	IST10	NS			NS			0.80			NS			NS			0.60		
Meadow Creek, above Blackfoot Reservoir	IST23	NS			0.18			-0.32	0.50	U	NS			####			0.11		
Stewart Creek, above Diamond Creek	IST23	0.90			NS			0.10	0.50	U	0.78			NS			0.90		
Timber Creek, above Diamond Creek	IST23	####			0.25			-0.36	0.50	U	0.22			0.28			0.34		
Little Blackfoot River, upstream of Henry cutoff road	IST25	NS			NS			-0.32	0.50	U	NS			NS			0.12		

Station Name	Stati	Copper									Molybdenum								
		1999			2001			2004			1999			2001			2004		
		Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	IRV01	NS			NS			5.0	9.3	U	NS			NS			0.76	0.78	U
Little Blackfoot River, above Reese Creek	IST04	NS			3.7		J	5.0	9.3	U	NS			0.84			2.6		
North Fork Wooley Valley Creek, above Ballard Mine	IST09	NS			NS			4.1	9.3	U	NS			NS			1.6		
Caldwell Creek, below Phosphoria Formation outcrop	IST10	NS			NS			8.8	9.3	U	NS			NS			2.4		
Meadow Creek, above Blackfoot Reservoir	IST23	NS			4.3		J	1.8	9.3	U	NS			0.89			0.68	0.78	U
Stewart Creek, above Diamond Creek	IST23	NA			NS			5.1	9.3	U	NA			NS			0.9		
Timber Creek, above Diamond Creek	IST23	NA			4.3		J	2.3	9.3	U	NA			0.71			0.72	0.78	U
Little Blackfoot River, upstream of Henry cutoff road	IST25	NS			NS			2.9	9.3	U	NS			NS			0.91		

Station Name	Stati	Nickel									Vanadium									Zinc								
		1999			2001			2004			1999			2001			2004			1999			2001			2004		
		Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag	Fall	RL	Flag
Blackfoot Reservoir Delta, at Meadow Creek	IRV01	NS			NS			NA			NS			NS			NA			NS			NS			38		
Little Blackfoot River, above Reese Creek	IST04	NS			0.88			NA			NS			2.0			NA			NS			40		J	28		
North Fork Wooley Valley Creek, above Ballard Mine	IST09	NS			NS			NA			NS			NS			NA			NS			NS			27		
Caldwell Creek, below Phosphoria Formation outcrop	IST10	NS			NS			NA			NS			NS			NA			NS			NS			64		
Meadow Creek, above Blackfoot Reservoir	IST23	NS			0.49			NA			NS			0.76			NA			NS			23		J	12		
Stewart Creek, above Diamond Creek	IST23	NA			NS			NA			NA			NS			NA			NA			NS			52		
Timber Creek, above Diamond Creek	IST23	NA			0.48			NA			NA			0.52			NA			NA			29		J	28		
Little Blackfoot River, upstream of Henry cutoff road	IST25	NS			NS			NA			NS			NS			NA			NS			NS			23		

Notes:
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Table B7: Upland Historical Background Data - COPC (mg/kg dry weight) - Uncensored Data [a]

Station Name	Station ID	Upland Soil									Upland Vegetation								
		Selenium									Selenium								
		1998			2000			2001			1998			2000			2001		
		Summer	RL	Flag	Summer	RL	Flag	Summer	RL	Flag	Summer	RL	Flag	Summer	RL	Flag	Summer	RL	Flag
Caldwell Creek Outcrop Quadrant 1	BB002-1	0.78			NS			NS			0.16			NS			NS		
Caldwell Creek Outcrop Quadrant 2	BB002-2	1.4			NS			NS			0.11			NS			NS		
Caldwell Creek Outcrop Quadrant 3	BB002-3	1.4			NS			NS			0.020			NS			NS		
Caldwell Creek Outcrop Quadrant 4	BB002-4	1.1			NS			NS			0.040			NS			NS		
Caldwell Creek Outcrop Quadrant 5	BB002-5	0.84			NS			NS			0.14			NS			NS		
Background Phosphoria Outcrop, SE of Conda Mine	BB004-1	NS			NS			0.41			NS			NS			0.052		
Background Phosphoria Outcrop, SE of Conda Mine	BB004-2	NS			NS			0.44			NS			NS			0.099		
Background Phosphoria Outcrop, SE of Conda Mine	BB004-3	NS			NS			0.47			NS			NS			0.12		
Background Phosphoria Outcrop, near N. End of Slug Valley	BB005-1	NS			NS			0.017	0.040	U	NS			NS			0.10		
Background Phosphoria Outcrop, near N. End of Slug Valley	BB005-2	NS			NS			0.73			NS			NS			0.11		
Background Phosphoria Outcrop, near N. End of Slug Valley	BB005-3	NS			NS			0.85			NS			NS			0.11		
Background Phosphoria Outcrop, near Stewart Creek drainage	BB006-1	NS			NS			0.60			NS			NS			0.12		
Background Phosphoria Outcrop, near Stewart Creek drainage	BB006-2	NS			NS			0.61			NS			NS			0.20		
Background Phosphoria Outcrop, near Stewart Creek drainage	BB006-3	NS			NS			0.78			NS			NS			0.21		
Background Phosphoria Outcrop, near Diamond Creek drainage	BB007-1	NS			NS			2.5			NS			NS			0.32		
Background Phosphoria Outcrop, near Diamond Creek drainage	BB007-2	NS			NS			2.8			NS			NS			0.38		
Background Phosphoria Outcrop, near Diamond Creek drainage	BB007-3	NS			NS			3.3			NS			NS			0.42		
Enoch Valley Mine Topsoil Stockpile 1	TOST01	NS			3.1			NS			NS			1.2			NS		
Enoch Valley Mine Topsoil Stockpile 2	TOST02	NS			1.2			NS			NS			0.094			NS		
Enoch Valley Mine Topsoil Stockpile 3	TOST03	NS			1.2			NS			NS			0.15			NS		
South Rasmussen Background 1	SRBG01	NS			1.2			NS			NS			0.15			NS		
South Rasmussen Background 2	SRBG02	NS			3.6			NS			NS			0.57			NS		
South Rasmussen Background 3	SRBG03	NS			3.3			NS			NS			0.13			NS		
South Rasmussen Background 4	SRBG04	NS			2.4			NS			NS			0.23			NS		
South Rasmussen Background 5	SRBG05	NS			2.3			NS			NS			0.22			NS		
South Rasmussen Background 6	SRBG06	NS			2.4			NS			NS			0.16			NS		

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Appendix C
Supplemental Surface Water Information

Appendix C: Surface Water Field Data

Table C1: Surface Water Field Parameters

Feature	*Sampling Station*	*Station ID*	*Air Temp*	*Water Temp (C)*	*pH*	*Cond (mS/cm)*	*Spec Cond*	*DO (mg/L)*	*ORP (mV)*	*Turbidity (NTU)*	*Calculated HCO_3*	*Calculated CO_3 (mg/L)*
Blackfoot River	Above Blackfoot Reservoir	MST232	49	14	7.33	340	429	6.92	269	8.52	275	0.145
	Below Woodall Mountain Creek	MST231[a]	NR	14	7.71	339	435	8.38	264	10.45	276	0.399
	Below Ballard Creek	MST019	NR	13	8.41	276	358	6.52	208	5.44	230	1.321
	Below State Land Creek	MST020	NR	14	8.40	279	354	68.00	216	4.61	226	1.348
	Above State Land Creek	MST230[a]	NR	14	8.54	277	350	4.85	248	4.88	213	1.784
	Below Trail Creek	MST021[a]	NR	15	8.59	284	350	5.40	264	5.11	225	2.356
	Below Wooley Valley Creek	MST022	70	16	8.64	284	344	10.20	367	4.01	229	2.810
	Below Dry Valley Creek, (1997 #20)	MST023	70	11	8.53	251	348	10.07	228	5.52	234	1.441
	Above Dry Valley Creek, (1997 #19)	MST024	70	12	8.59	255	343	10.79	225	5.21	229	1.755
	Below Wooley Range Ridge Creek	MST025	70	14	8.59	272	343	9.58	268	5.47	228	2.172
	Above Wooley Range Ridge Creek	MST026	NR	13	8.66	267	346	10.18	197	4.18	215	2.186
	Below Angus Creek	MST027	66	6	8.97	216	334	10.37	314	6.61	218	2.423
	Above Diamond Creek Rd.	MST028	NR	8	8.44	226	340	10.95	28	7.44	217	0.815
	Below Spring Creek	MST229	NR	11	8.48	232	339	10.80	281	6.04	213	1.170
	Above Spring Creek	MST029	70	15	8.51	268	335	9.83	339	11.69	152	1.276
Meadow Creek	Above Blackfoot Reservoir	MST235	64	15	8.78	270	331	7.37	210	3.99	144	2.321
Little Blackfoot River	Above Blackfoot Reservoir	MST234[a]	55	16	7.33	793	955	8.12	204	0.71	562	0.389
	Below Long Valley Creek	MST043[a]	NR	13	30.82	724	941	4.27	148	7.81	504	0.654
	Immediately below Henry Mine (1997 #24)	MST044	76	16	8.48	634	768	8.02	244	1.99	220	2.031
	Above Henry Creek (1997 #23)	MST045	83	23	9.13	665	689	9.01	192	4.10	158	11.881
	Below Lone Pine Creek	MST046	NR	13	7.92	267	348	4.71	159	2.07	226	0.404
	Above Lone Pine Creek	MST047	NR	15	8.80	780	1124	7.07	138	10.02	36	0.706
	Below Reese Creek	MST048	NR	10	8.22	222	312	4.67	183	11.46	202	0.559
	Above Reese Creek	MST049	NR	12	8.21	220	292	5.26	207	4.38	183	0.600
	Upstream of Henry cutoff road	MST254[a]	56	15	8.30	234	290	8.23	93	3.04	167	0.854
Lone Pine Creek	Above Little Blackfoot River	MST053	NR	15	8.09	277	344	5.82	175	2.49	217	0.670
	Above spring-fed creek	MST054	NR	8	8.24	273	401	5.70	215	16.03	247	0.636
	Below Strip Mine Creek	MST055	69	18	8.65	341	394	8.92	210	12.45	227	3.444
	Above Strip Mine Creek	MST056	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Above West Fork Lone Pine Creek	MST058	60	12	7.82	325	437	7.62	213	1.40	270	0.360
	Spring Fed Tributary Above Lone Pine Creek	MST277[a]	48	11	7.62	387	519	5.14	178	8.42	346	0.292
East Fork Lone Pine Creek	Below Wooley Valley Mine	MST226	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
West Fork Lone Pine Creek	Above tributary to West Fork Lone Pine Creek	MST064	55	10	7.95	344	487	9.24	229	0.97	269	0.406
	Above Lone Pine Creek	MST057	55	11	8.09	326	447	9.24	223	10.78	234	0.520
Tributary to West Fork Lone Pine Creek	Above West Fork Lone Pine Creek	MST276	60	12	8.18	310	403	10.76	233	1.87	227	0.680
North Fork Lone Pine Creek	Northeast and above East Fork Lone Pine Creek	MST275	55	15	8.40	144	191	6.52	269	38.47	71	0.421
West Rasmussen Ridge Creek #1	Above Lone Pine Creek	MST059	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
West Rasmussen Ridge Creek #2	Above Lone Pine Creek	MST060	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
West Rasmussen Ridge Creek #3	Above Lone Pine Creek	MST061	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Strip Mine Creek	Above Lone Pine Creek	MST062	60	11	8.25	285	391	23.53	197	5.00	230	0.761
	Below Henry Mine	MST063	60	12	8.10	494	602	11.45	232	6.35	324	0.892
Angus Creek	Above Blackfoot River	MST126[a]	59	13	8.30	296	387	8.39	207	2.33	202	0.919
	Below No Name Creek	MST127	NR	10	8.39	265	375	9.54	268	4.94	54	0.226
	Above No Name Creek and below Rasmussen Creek	MST132	NR	7	8.37	251	386	81.60	275	6.37	205	0.623
	Above Rasmussen Creek	MST128	NR	6	8.34	253	398	8.08	218	6.69	211	0.554
	R-B&M-10, below Wooley Valley Mine	MST129	NR	10	8.45	304	436	10.63	256	7.32	205	0.953
	R-B&M-12, below Upper Angus Creek Reservoir	MST130	NR	7	7.52	439	713	4.55	243	1.95	100	0.046
West Fork Rasmussen Creek	Above Rasmussen Creek	MST274	NR	11	8.18	303	423	9.08	-209	1.53	177	0.481
Rasmussen Creek	Above Angus Creek	MST131	NR	15	8.53	275	246	8.20	-134	4.92	183	1.498
	M-B&M-1, below Enoch Valley Mine (1997 #38)	MST133	56	15	8.16	223	279	10.35	279	3.23	143	0.512
	Below West Pond Creek	MST134	NR	12	8.84	225	384	104.00	71	5.13	118	1.688
	Above West Pond Creek	MST135	NR	10	7.30	249	352	119.60	99	1.40	134	0.045
	Headwaters near Enoch Valley Mine Shop Pond	MST136	NR	15	8.11	548	855	8.87	84	0.40	73	0.271
East Fork Rasmussen Creek	Above Rasmussen Creek	MST143	NR	11	8.31	409	558	9.13	291	48.02	58	0.235
	Headwaters	MST269	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
West Pond Creek	Headwaters, below West Pond	MST144	70	12	7.10	641	859	7.31	214	2.88	136	0.037
Long Valley Creek	Downstream of station MST050	MST270	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Above Little Blackfoot River and Below East Fork Long Valley Creek	MST271	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Below Ballard Mine, (ponded area)	MST050	54	11	10.82	185	253	10.69	153	9.17	16	18.458
East Fork Long Valley Creek	Below Henry Mine	MST051	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Henry Creek	Above Little Blackfoot River	MST052	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry

Table C1: Surface Water Field Parameters

Feature	*Sampling Station*	*Station ID*	*Air Temp*	*Water Temp (C)*	*pH*	*Cond (mS/cm)*	*Spec Cond*	*DO (mg/L)*	*ORP (mV)*	*Turbidity (NTU)*	*Calculated HCO_3*	*Calculated CO_3 (mg/L)*
Ballard Creek	Above Blackfoot River	MST066	53	14	7.70	393	495	7.65	284	3.28	167	0.211
	Headwaters	MST067	37	5	6.51	887	1373	6.46	240	1.98	300	0.013
West Fork Ballard Creek	Headwaters	MST068	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
Short Creek	Below Ballard Mine	MST069	NR	14	7.40	1776	2236	8.68	244	2.46	271	0.215
Wooley Valley Creek	Above Blackfoot River	MST088	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Above Loadout Creek at road	MST272	48	12	8.27	359	480	9.82	250	3.25	221	0.833
	Above ponding and below MST089	MST273	50	14	7.62	443	566	9.72	241	19.00	319	0.337
	Below North Fork Wooley Valley Creek	MST089	51	10	7.76	94	317	10.13	265	1.96	179	0.176
	Above North Fork Wooley	MST090	52	11.4	7.77	289	392	7.30	254	0.93	237	0.269
North Fork Wooley Valley Creek	Above Wooley Valley Creek	MST092	46	11.1	8.24	168	229	8.06	263	10.81	101	0.311
	Above Ballard Mine	MST093	51	10.2	8.29	189	269	10.22	325	3.74	119	0.386
Spring-fed tributary #1 of North Fork Wooley Valley Creek	Below Ballard Mine	MST094	49	14.0	8.29	269	334	10.66	248	6.03	190	0.878
Spring-fed tributary #2 of North Fork Wooley Valley Creek	Below Ballard Mine	MST095	47	6.5	7.93	561	863	6.83	298	8.98	263	0.306
Tributary of North Fork Wooley Valley Creek	Below Ballard Mine	MST096	47	11.1	7.75	299	392	4.19	319	9.45	232	0.245
Caldwell Creek	Below Phosphoria Formation outcrop (1997 #62)	MST101	58	11.7	8.52	341	457	9.36	291	4.93	260	1.730
Stewart Creek	Above Diamond Creek	MST236	61	4.7	8.30	203	332	10.14	269	8.96	146	0.301
Timber Creek	Above Diamond Creek	MST237	55	6.8	8.58	225	345	9.94	240	3.86	192	0.920
Blackfoot Reservoir Delta	At Blackfoot River	MRV011	57	13.6	7.69	336	430	7.57	269	11.75	270	0.312
	At Little Blackfoot River	MRV016	59	13.9	7.15	736	923	5.74	285	0.26	523	0.197
	At Meadow Creek	MRV017	58	13.2	8.60	274	354	7.85	211	5.43	158	1.403
Springs	Hedin Spring	MSG001	64	9.2	7.71	301	439	3.90	130	3.60	242	0.199
	Taylor Spring	MSG002	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Garden Hose Spring	MSG003	NR	8.8	7.66	526	754	6.57	277	0.49	338	0.256
	Holmgren Spring	MSG004	44	8.8	8.30	336	485	9.89	265	184.00	282	0.882
	Cattle Spring	MSG005	40	6.7	8.08	352	542	8.51	309	1.15	321	0.506
	Ballard Mine Southeast Spring	MSG006	58	5.9	7.88	743	1177	7.31	321	0.96	282	0.290
Seeps	Enoch Valley Mine West Dump Seep	MDS025	72	8.5	6.25	940	1110	25.50	143	19.52	219	0.007
	Enoch Valley Mine South Dump Seep	MDS026	50	8.9	6.96	1233	1792	28.00	214	6.50	399	0.069
	Henry Mine South Pit Overburden Dump Seep (1997 #28)	MDS016	45	11.6	7.71	1128	1523	5.82	288	5.26	320	0.386
	Henry Mine South Pit Overburden Dump Limestone Drain (formerly FD002) (1997 #29)	MDS022	60	14.7	7.92	691	863	13.21	241	1.86	494	1.160
	Ballard Mine Pit #2 Upper Dump Seep	MDS030	42	8.5	7.43	534	788	8.17	296	10.41	386	0.168
	Ballard Mine Pit #2 Lower Dump Seep South	MDS031	44	6.6	7.57	531	800	9.06	243	4.15	293	0.149
	Ballard Mine Pit #2 Lower Dump Seep North	MDS032	44	9.8	7.74	1035	1458	8.19	260	15.85	215	0.236
	Ballard Mine Goat Seep	MDS033	49	9.7	7.64	1134	1605	7.67	289	2.64	349	0.306
Ponds	Henry Mine Henry Pond	MSP014	54	11.0	6.45	851	1169	5.02	219	0.00	112	0.007
	Henry Mine Smith Pond	MSP015	52	12.9	8.27	673	875	5.50	280	0.71	289	1.302
	Henry Mine Center Henry Pond	MSP016[a]	69	15.6	8.50	540	655	10.82	211	5.00	216	2.036
	Henry Mine South Pit Pond	MSP055	53	9.9	8.15	777	1092	7.48	262	5.72	103	0.280
	Ballard Mine Dredge Pond	MSP010	56	9.4	8.15	360	510	7.94	260	5.28	288	0.675
	Ballard Mine Upper Elk Pond	MSP011[a]	65	10.2	8.62	147	207	8.41	271	0.65	115	0.803
	Ballard Mine Lower Elk Pond	MSP012	38	8.8	8.51	154	223	9.27	256	4.63	107	0.504
	Ballard Mine Northeast Pond	MSP013	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
	Ballard Mine Pit #4 Stock Pond	MSP059	NR	10.3	8.92	1207	1681	9.32	248	2.30	86	1.521
	Ballard Mine Pit #6 Pond	MSP062	46	9.4	8.44	234	334	8.71	271	14.46	202	0.882
	Enoch Valley Mine South Pond	MSP017[a]	NR	14.8	7.92	1004	1266	8.05	218	2.48	126	0.317
	Enoch Valley Mine Keyhole Pond	MSP018	NR	8.4	6.34	1491	2108	9.77	243	1.84	152	0.006
	Enoch Valley Mine Bat Cave Pond	MSP019	NR	10.5	7.44	432	579	7.27	190	1.60	97	0.050
	Enoch Valley Mine West Pond	MSP020	NR	12.3	9.22	453	605	9.81	224	5.57	67	2.425
	Enoch Valley Mine Stock Pond	MSP021	NR	11.2	7.88	1042	1417	10.68	240	5.09	186	0.316
	Enoch Valley Mine Tipple Pond	MSP022	NR	9.7	9.97	663	933	8.78	-185	4.76	45	7.781
	Enoch Valley Mine Haul Road Pond	MSP023	NR	10.6	9.50	407	564	7.22	56	17.41	76	4.483
	Enoch Valley Mine Shop Pond	MSP031	NR	10.5	7.69	401	553	5.83	-142	3.22	110	0.099

Notes

[a] The average of the QA station replicate sample results are reported.

NR - Not reported.

Table C2: Calculated Hardness-Dependent Criteria for Surface Water							
Feature	***Sampling Station***	***Station ID***	***Hardness*** [a]	***Calculated Cd Criteria***	***Calculated Cr Criteria***	***Calculated Ni Criteria***	***Calculated Zn Criteria***
Blackfoot River	Above Blackfoot Reservoir	MST232	232	0.00044	NA	0.11	0.24
	Below Woodall Mountain Creek	MST231	229	0.00044	NA	0.11	0.24
	Below Ballard Creek	MST019	203	0.00040	NA	0.095	0.22
	Below State Land Creek	MST020	188	0.00038	NA	0.089	0.20
	Above State Land Creek	MST230	192	0.00039	NA	0.090	0.21
	Below Trail Creek	MST021	193	0.00039	NA	0.091	0.21
	Below Wooley Valley Creek	MST022	193	0.00039	NA	0.091	0.21
	Below Dry Valley Creek, (1997 #20)	MST023	200	0.00040	NA	0.094	0.21
	Above Dry Valley Creek, (1997 #19)	MST024	190	0.00038	NA	0.090	0.20
	Below Wooley Range Ridge Creek	MST025	193	0.00039	NA	0.091	0.21
	Above Wooley Range Ridge Creek	MST026	201	0.00040	NA	0.094	0.21
	Below Angus Creek	MST027	190	0.00038	NA	0.090	0.20
	Above Diamond Creek Rd.	MST028	196	0.00039	NA	0.092	0.21
	Below Spring Creek	MST229	194	0.00039	NA	0.091	0.21
	Above Spring Creek	MST029	193	0.00039	NA	0.091	0.21
Meadow Creek	Above Blackfoot Reservoir	MST235	147	0.00032	NA	0.072	0.16
Little Blackfoot River	Above Blackfoot Reservoir	MST234	509	0.00064	NA	0.17	0.38
	Below Long Valley Creek	MST043	522	0.00064	NA	0.17	0.38
	Immediately below Henry Mine (1997 #24)	MST044	285	0.00051	NA	0.13	0.29
	Above Henry Creek (1997 #23)	MST045	259	0.00048	NA	0.12	0.26
	Below Lone Pine Creek	MST046	187	0.00038	NA	0.088	0.20
	Above Lone Pine Creek	MST047	423	0.00064	NA	0.168	0.38
	Below Reese Creek	MST048	166	0.00035	NA	0.080	0.18
	Above Reese Creek	MST049	154	0.00033	NA	0.075	0.17
	Upstream of Henry cutoff road	MST254	144	0.00032	NA	0.071	0.16
Lone Pine Creek	Above Little Blackfoot River	MST053	185	0.00038	NA	0.088	0.20
	Above spring-fed creek	MST054	208	0.00041	NA	0.097	0.22
	Below Strip Mine Creek	MST055	194	0.00039	NA	0.091	0.21
	Above Strip Mine Creek	MST056	Dry	Dry	Dry	Dry	Dry
	Above West Fork Lone Pine Creek	MST058	245	0.00046	0.154	0.11	0.25
	Spring Fed Tributary Above Lone Pine Creek	MST277	269	0.00049	0.167	0.12	0.27
East Fork Lone Pine Creek	Below Wooley Valley Mine	MST226	Dry	Dry	Dry	Dry	Dry
West Fork Lone Pine Creek	Above tributary to West Fork Lone Pine Creek	MST064	263	0.00048	0.164	0.12	0.27
	Above Lone Pine Creek	MST057	228	0.00044	NA	0.10	0.24
Tributary to West Fork Lone Pine Creek	Above West Fork Lone Pine Creek	MST276	236	0.00045	0.150	0.11	0.24
North Fork Lone Pine Creek	Northeast and above East Fork Lone Pine Creek	MST275	57	0.00017	0.046	0.032	0.073
West Rasmussen Ridge Creek #1	Above Lone Pine Creek	MST059	Dry	Dry	Dry	Dry	Dry
West Rasmussen Ridge Creek #2	Above Lone Pine Creek	MST060	Dry	Dry	Dry	Dry	Dry
West Rasmussen Ridge Creek #3	Above Lone Pine Creek	MST061	Dry	Dry	Dry	Dry	Dry
Strip Mine Creek	Above Lone Pine Creek	MST062	210	0.00041	NA	0.097	0.22
	Below Henry Mine	MST063	341	0.00058	NA	0.15	0.33
Angus Creek	Above Blackfoot River	MST126	213	0.00042	NA	0.098	0.22
	Below No Name Creek	MST127	139	0.00031	NA	0.069	0.16
	Above No Name Creek and below Rasmussen Creek	MST132	211	0.00041	NA	0.098	0.22
	Above Rasmussen Creek	MST128	214	0.00042	NA	0.099	0.23
	R-B&M-10, below Wooley Valley Mine	MST129	243	0.00046	NA	0.11	0.25
	R-B&M-12, below Upper Angus Creek Reservoir	MST130	357	0.00059	NA	0.15	0.35
West Fork Rasmussen Creek	Above Rasmussen Creek	MST274	210	0.00041	0.136	0.097	0.22
Rasmussen Creek	Above Angus Creek	MST131	177	0.00037	NA	0.084	0.19
	M-B&M-1, below Enoch Valley Mine (1997 #38)	MST133	135	0.00030	NA	0.067	0.15
	Below West Pond Creek	MST134	204	0.00040	NA	0.095	0.22
	Above West Pond Creek	MST135	168	0.00035	NA	0.081	0.18
	Headwaters near Enoch Valley Mine Shop Pond	MST136	407	0.00064	0.231	0.17	0.38
East Fork Rasmussen Creek	Above Rasmussen Creek	MST143	261	0.00048	NA	0.12	0.27
	Headwaters	MST269	Dry	Dry	Dry	Dry	Dry
West Pond Creek	Headwaters, below West Pond	MST144	516	0.00064	0.231	0.17	0.38
Long Valley Creek	Downstream of station MST050	MST270	Dry	Dry	Dry	Dry	Dry
	Above Little Blackfoot River and Below East Fork Long Valley Creek	MST271	Dry	Dry	Dry	Dry	Dry
	Below Ballard Mine, (ponded area)	MST050	102	0.00025	NA	0.053	0.12
East Fork Long Valley Creek	Below Henry Mine	MST051	Dry	Dry	Dry	Dry	Dry
Henry Creek	Above Little Blackfoot River	MST052	Dry	Dry	Dry	Dry	Dry
Ballard Creek	Above Blackfoot River	MST066	199	0.00040	0.130	0.093	0.21
	Headwaters	MST067	984	0.00064	0.231	0.17	0.38
West Fork Ballard Creek	Headwaters	MST068	Dry	Dry	Dry	Dry	Dry
Short Creek	Below Ballard Mine	MST069	1457	0.00064	0.231	0.17	0.38
Wooley Valley Creek	Above Blackfoot River	MST088	Dry	Dry	Dry	Dry	Dry
	Above Loadout Creek at road	MST272	258	0.00048	NA	0.12	0.26
	Above ponding and below MST089	MST273	305	0.00053	NA	0.13	0.30
	Below North Fork Wooley Valley Creek	MST089	172	0.00036	0.115	0.082	0.19
	Above North Fork Wooley Valley Creek	MST090	210	0.00041	NA	0.097	0.22

Table C2: Calculated Hardness-Dependent Criteria for Surface Water							
Feature	***Sampling Station***	***Station ID***	***Hardness*** [a]	***Calculated Cd Criteria***	***Calculated Cr Criteria***	***Calculated Ni Criteria***	***Calculated Zn Criteria***
North Fork Wooley Valley Creek	Above Wooley Valley Creek	MST092	114	0.00027	NA	0.058	0.13
	Above Ballard Mine	MST093	77	0.00021	0.060	0.042	0.095
Spring-fed tributary #1 of North Fork Wooley Valley Creek	Below Ballard Mine	MST094	210	0.00041	NA	0.097	0.22
Spring-fed tributary #2 of North Fork Wooley Valley Creek	Below Ballard Mine	MST095	510	0.00064	NA	0.17	0.38
Tributary of North Fork Wooley Valley Creek	Below Ballard Mine	MST096	307	0.00054	0.186	0.13	0.31
Caldwell Creek	Below Phosphoria Formation outcrop (1997 #62)	MST101	248	0.00046	NA	0.11	0.25
Stewart Creek	Above Diamond Creek	MST236	184	0.00038	0.122	0.087	0.20
Timber Creek	Above Diamond Creek	MST237	190	0.00038	NA	0.089	0.20
Blackfoot Reservoir Delta	At Blackfoot River	MRV011	228	0.00044	NA	0.10	0.24
	At Little Blackfoot River	MRV016	480	0.00064	NA	0.17	0.38
	At Meadow Creek	MRV017	157	0.00034	NA	0.076	0.17
Springs	Hedin Spring	MSG001	217	0.00042	0.140	0.10	0.23
	Taylor Spring	MSG002	Dry	Dry	Dry	Dry	Dry
	Garden Hose Spring	MSG003	412	0.00064	0.231	0.17	0.38
	Holmgren Spring	MSG004	265	0.00048	0.165	0.12	0.27
	Cattle Spring	MSG005	302	0.00053	0.183	0.13	0.30
	Ballard Mine Southeast Spring	MSG006	710	0.00064	0.231	0.17	0.38
Seeps	Enoch Valley Mine West Dump Seep	MDS025	846	0.00064	0.231	0.17	0.38
	Enoch Valley Mine South Dump Seep	MDS026	1229	0.00064	0.231	0.17	0.38
	Henry Mine South Pit Overburden Dump Seep (1997 #28)	MDS016	917	0.00064	0.231	0.17	0.38
	Henry Mine South Pit Overburden Dump Limestone Drain (formerly FD002) (1997	MDS022	502	0.00064	NA	0.17	0.38
	Ballard Mine Pit #2 Upper Dump Seep	MDS030	463	0.00064	0.231	0.17	0.38
	Ballard Mine Pit #2 Lower Dump Seep South	MDS031	435	0.00064	0.231	0.17	0.38
	Ballard Mine Pit #2 Lower Dump Seep North	MDS032	858	0.00064	0.231	0.17	0.38
	Ballard Mine Goat Seep	MDS033	955	0.00064	0.231	0.17	0.38
Ponds	Henry Mine Henry Pond	MSP014	687	0.00064	NA	0.17	0.38
	Henry Mine Smith Pond	MSP015	501	0.00064	NA	0.17	0.38
	Henry Mine Center Henry Pond	MSP016	367	0.00061	NA	0.16	0.36
	Henry Mine South Pit Pond	MSP055	638	0.00064	NA	0.17	0.38
	Ballard Mine Dredge Pond	MSP010	681	0.00064	NA	0.17	0.38
	Ballard Mine Upper Elk Pond	MSP011	107	0.00026	NA	0.055	0.13
	Ballard Mine Lower Elk Pond	MSP012	114	0.00027	NA	0.058	0.13
	Ballard Mine Northeast Pond	MSP013	Dry	Dry	Dry	Dry	Dry
	Ballard Mine Pit #4 Stock Pond	MSP059	82	0.00021	NA	0.044	0.10
	Ballard Mine Pit #6 Pond	MSP062	175	0.00036	NA	0.084	0.19
	Enoch Valley Mine South Pond	MSP017	797	0.00064	NA	0.17	0.38
	Enoch Valley Mine Keyhole Pond	MSP018	1446	0.00064	NA	0.17	0.38
	Enoch Valley Mine Bat Cave Pond	MSP019	307	0.00054	NA	0.13	0.31
	Enoch Valley Mine West Pond	MSP020	327	0.00056	NA	0.14	0.32
	Enoch Valley Mine Stock Pond	MSP021	886	0.00064	NA	0.17	0.38
	Enoch Valley Mine Tipple Pond	MSP022	488	0.00064	NA	0.17	0.38
	Enoch Valley Mine Haul Road Pond	MSP023	286	0.00051	NA	0.13	0.29
	Enoch Valley Mine Shop Pond	MSP031	160	0.00034	NA	0.077	0.18

Notes

[a] The average of the QA station replicate sample results are reported.

Hardness-dependent criteria have been calculated on raw, unrounded, uncensored, and calculated hardness results.

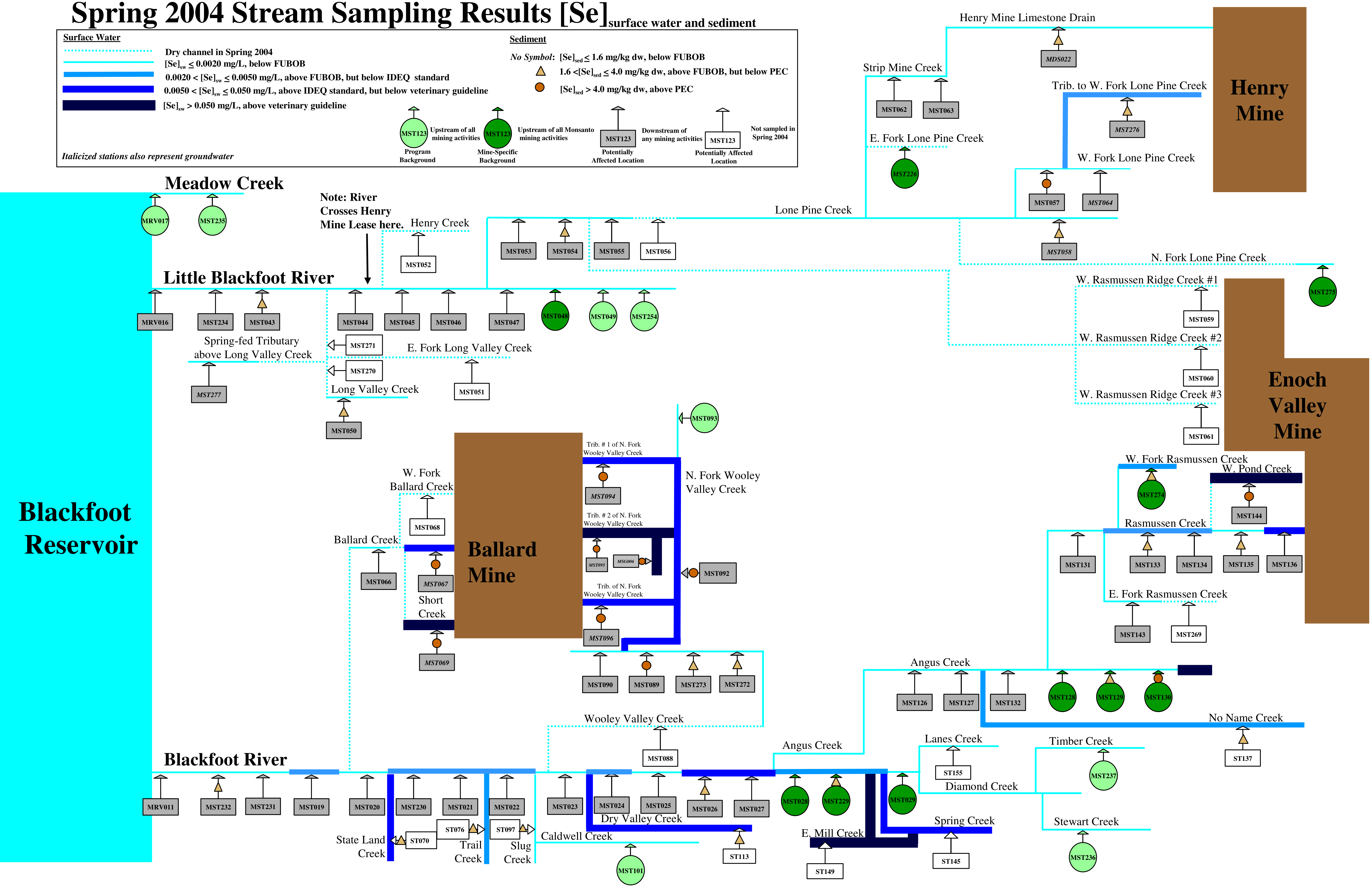
The resulting hardness-dependent criteria is provided as the PRBB on Table 5-1, Table 5-2, and Table 5-3 Enoch Valley (Henry, Ballard [respectively]) Mine-Aquatic and Riparian Media Censored Results.

NA - Not analyzed.

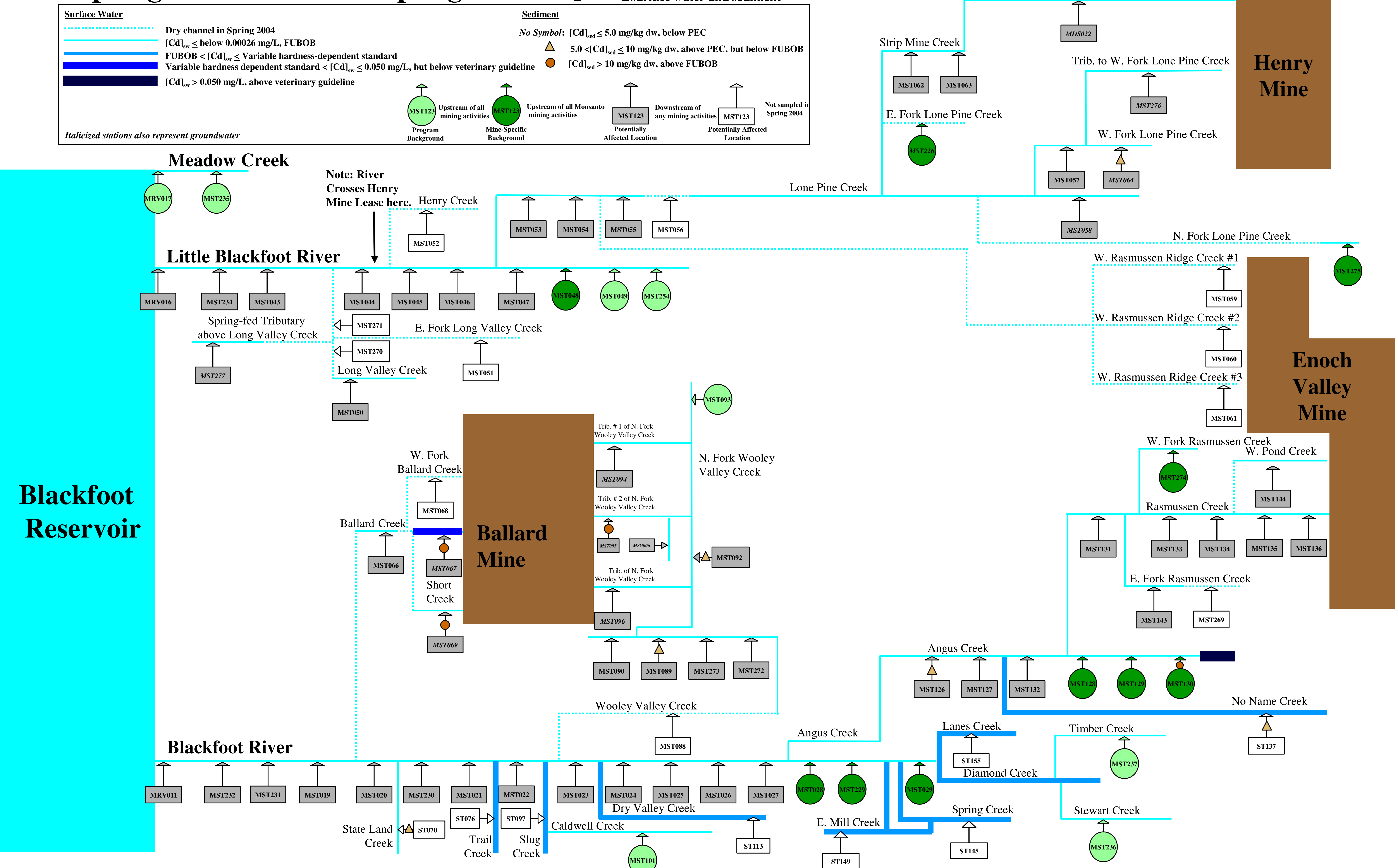
Appendix D
Surface Water and Sediment Spatial Wire Diagrams

Appendix D: Surface Water and Sediment Spatial Wire Diagrams

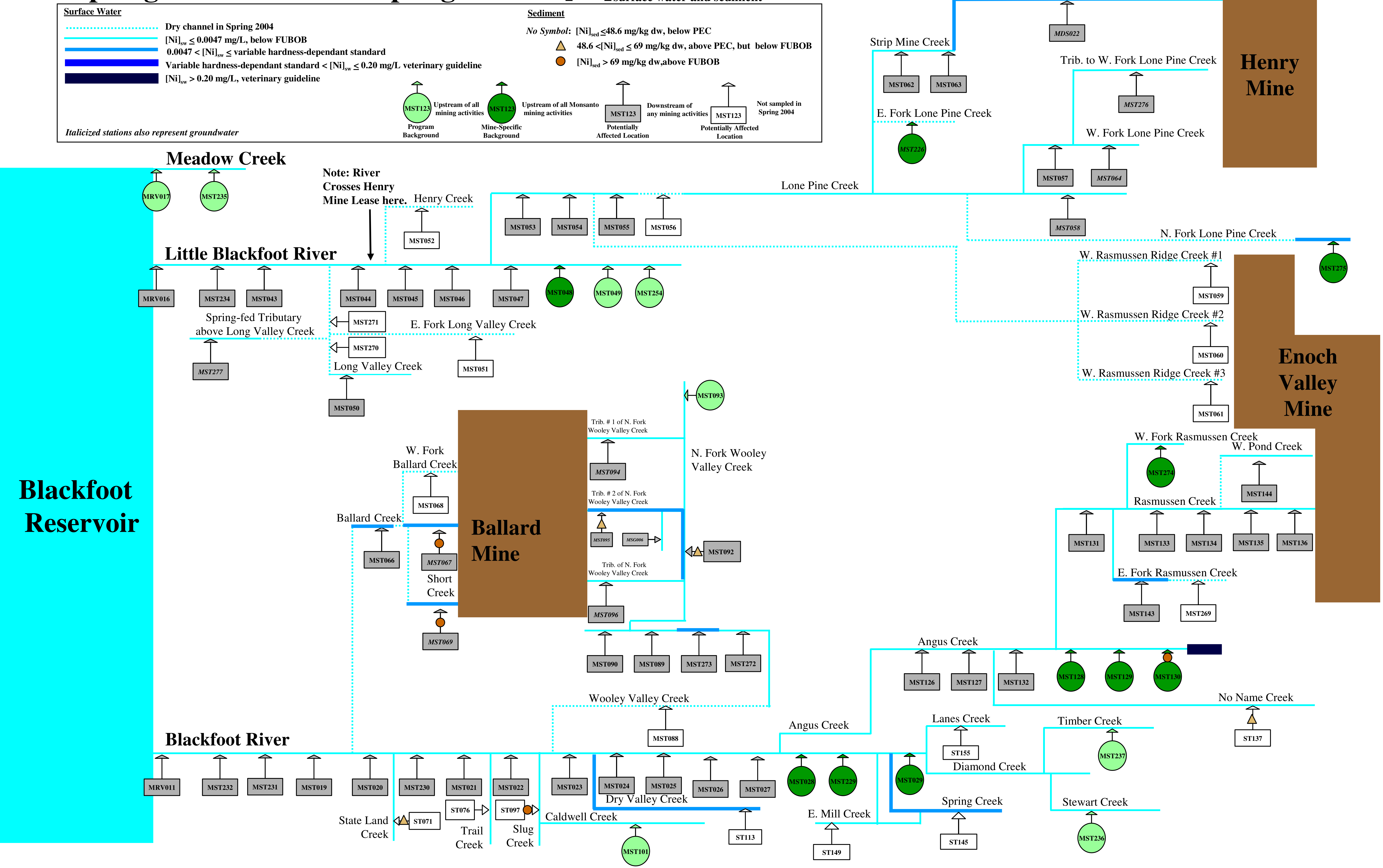
Spring 2004 Stream Sampling Results [Se] surface water and sediment



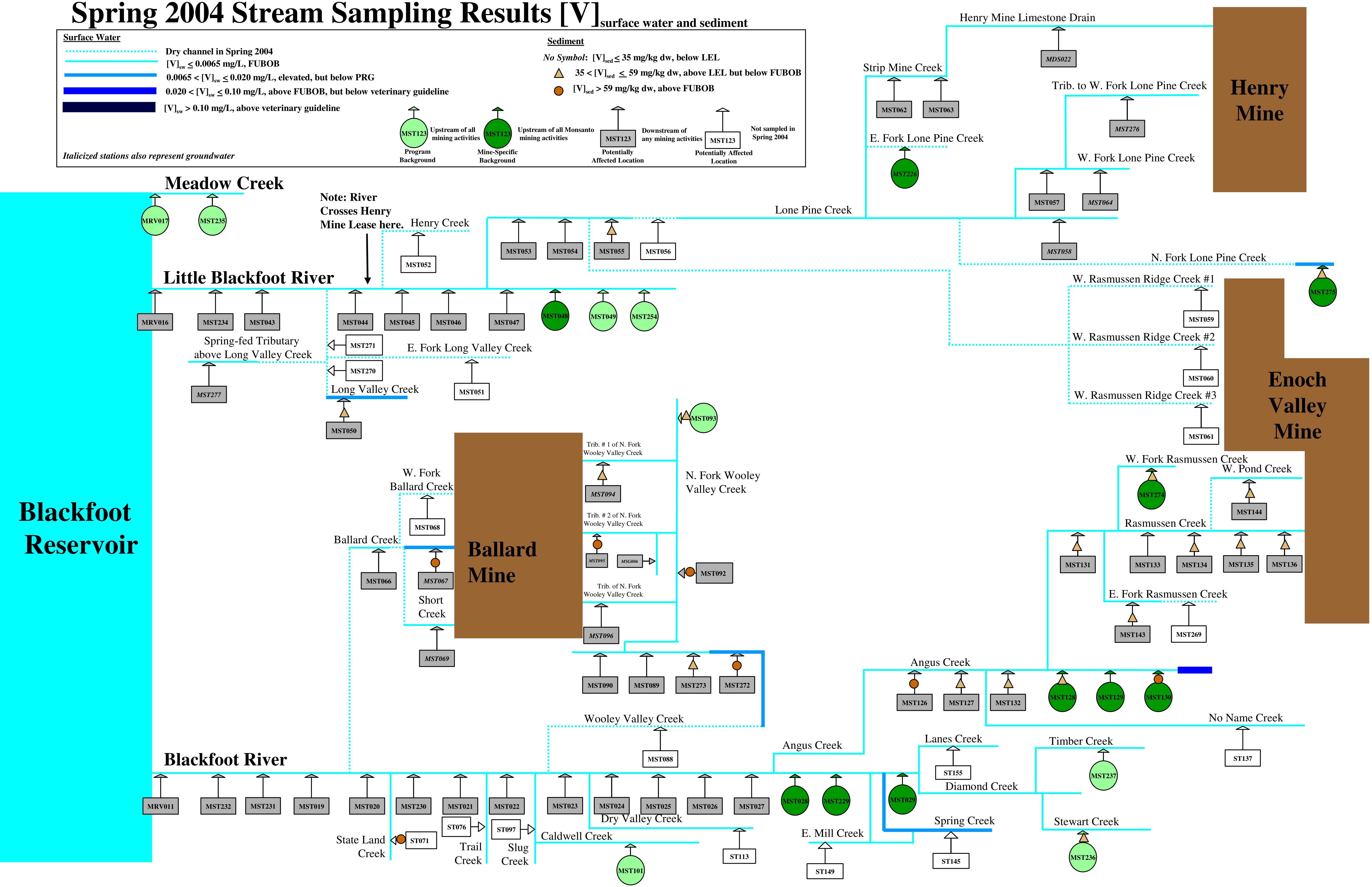
Spring 2004 Stream Sampling Results [Cd]$_{surface\ water\ and\ sediment}$



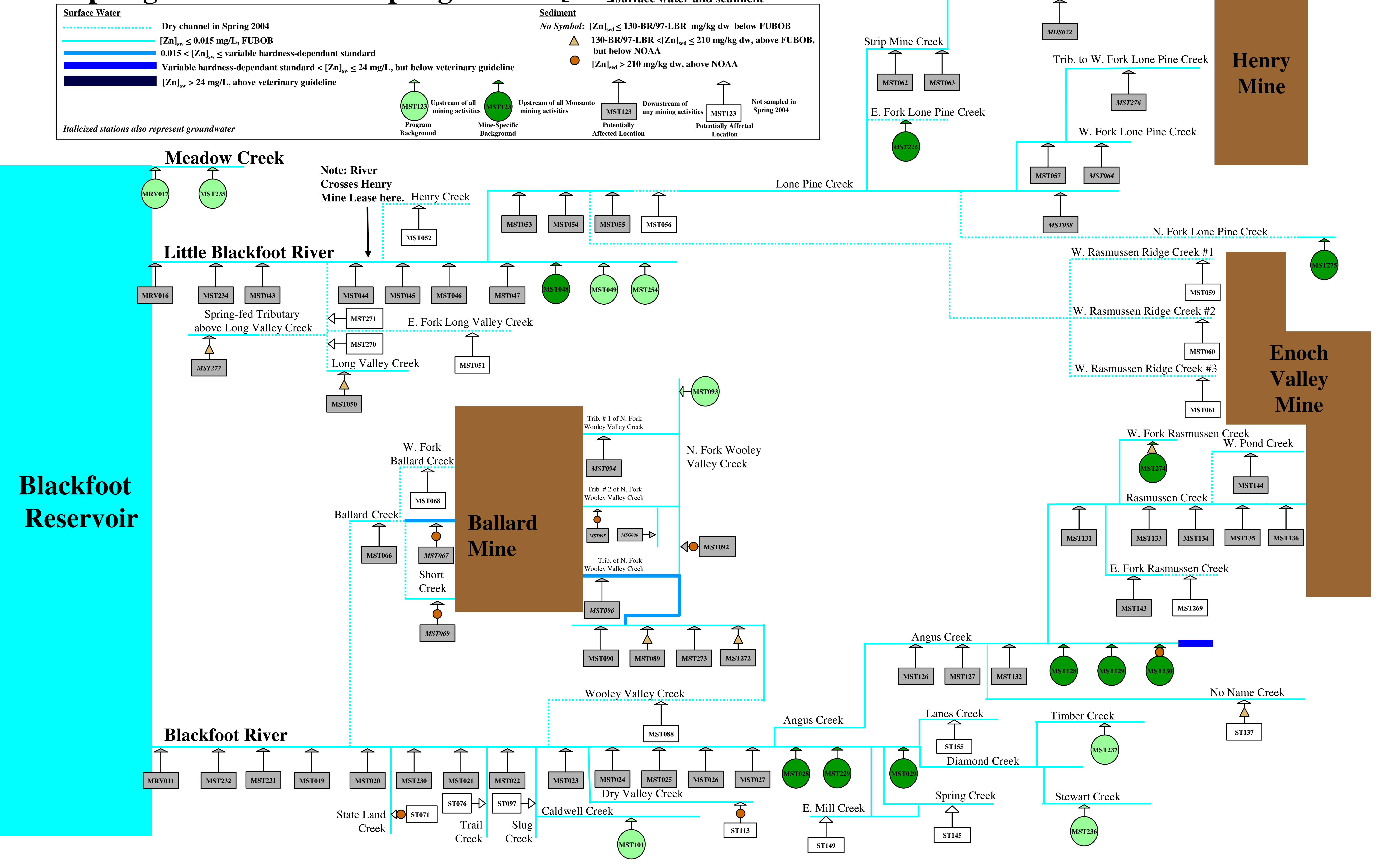
Spring 2004 Stream Sampling Results [Ni] surface water and sediment



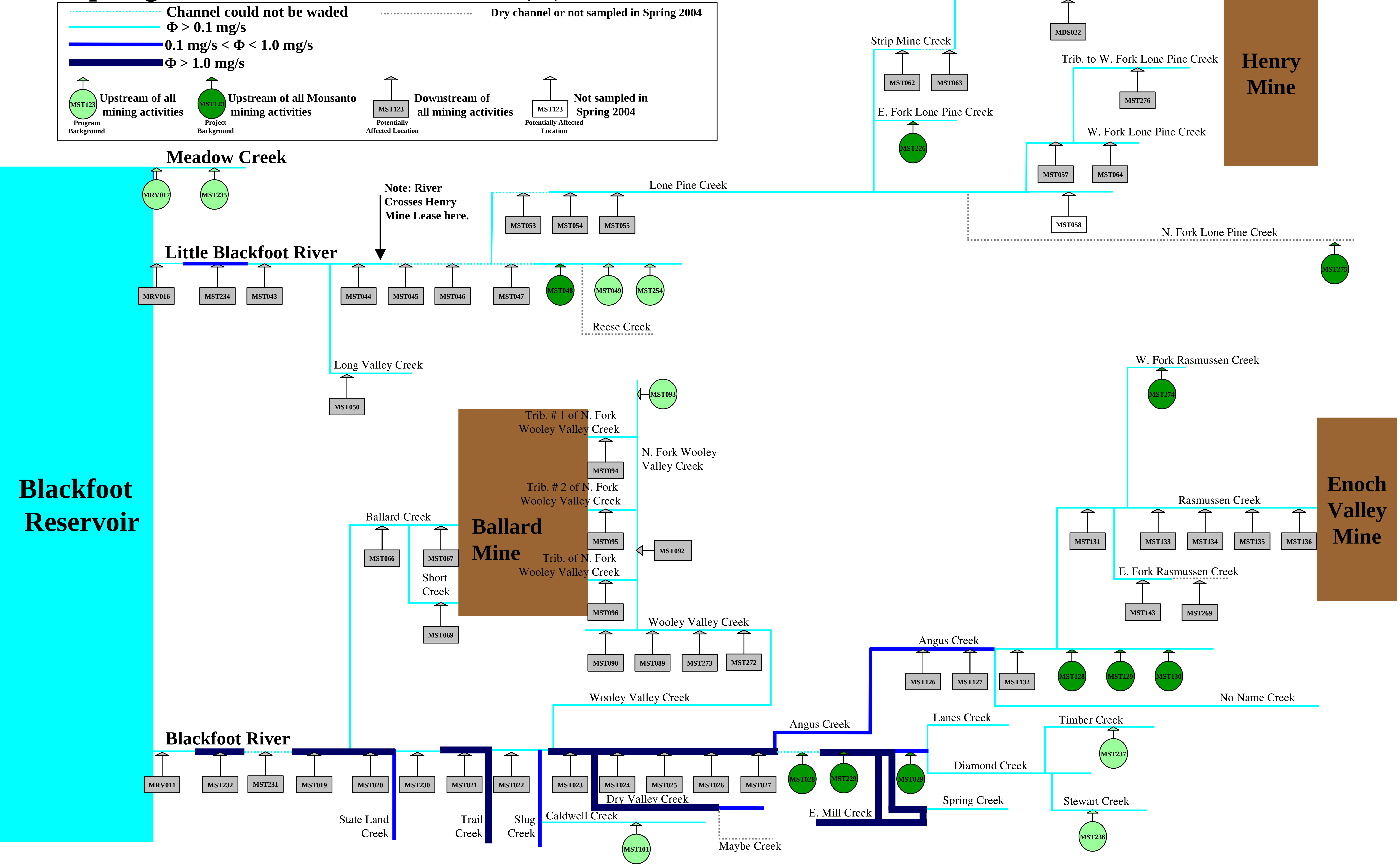
Spring 2004 Stream Sampling Results [V]surface water and sediment



Spring 2004 Stream Sampling Results [Zn]$_{\text{surface water and sediment}}$



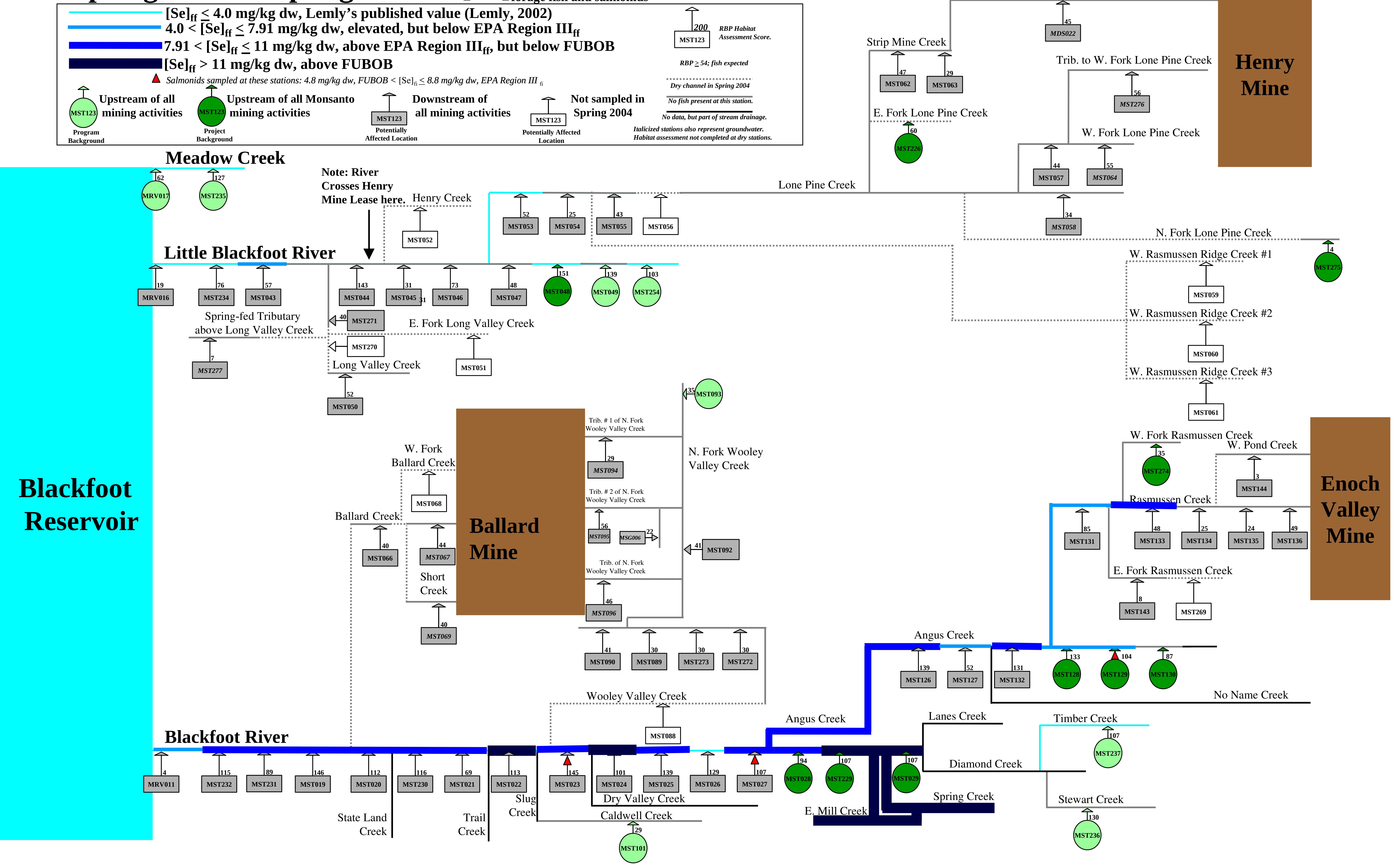
Spring 2004 Selenium Flux Results (Φ) surface water



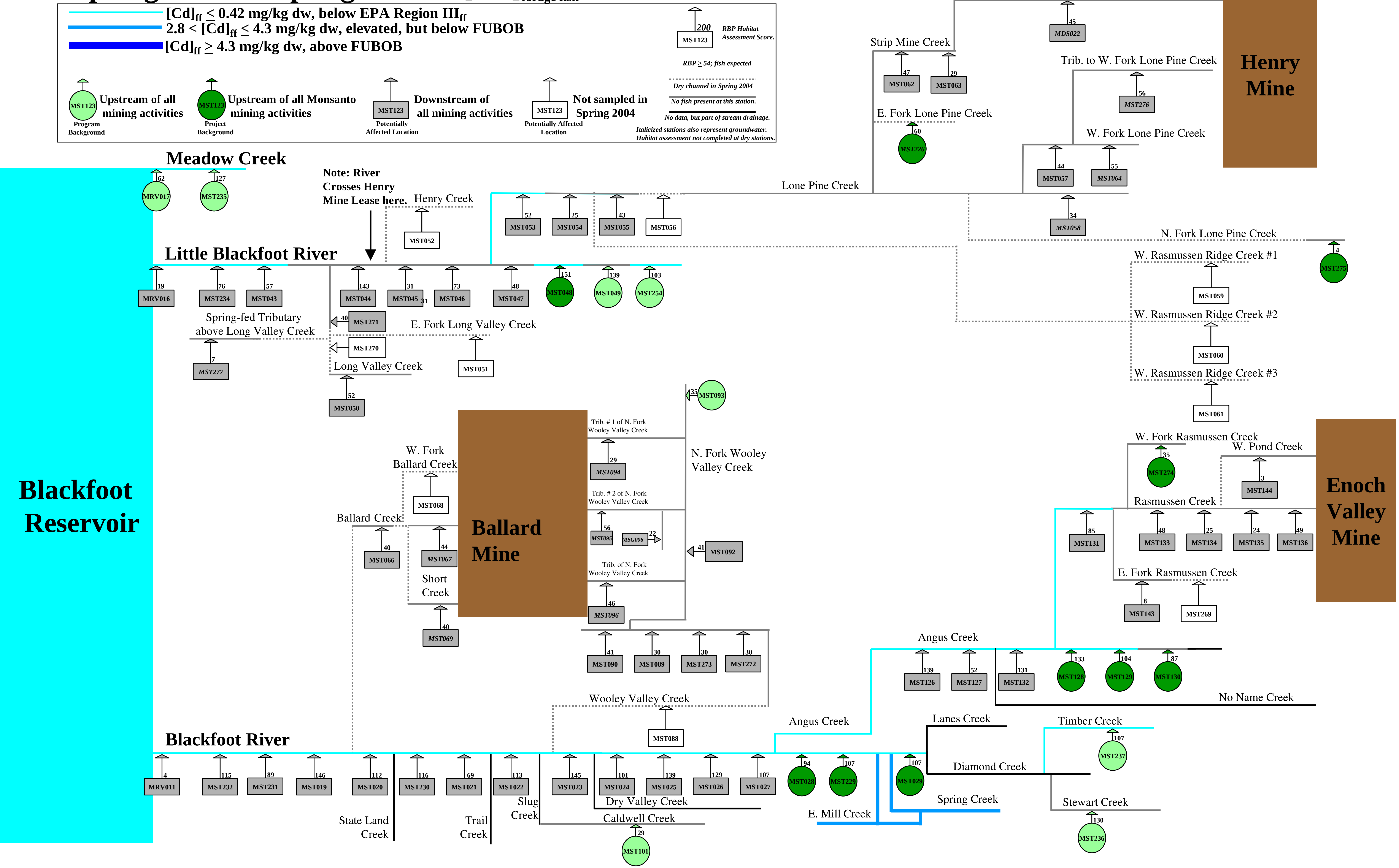
Appendix E
Salmonid Fish and Forage Fish Spatial Wire Diagrams

Appendix E: Salmonid Fish and Forage Fish Spatial Wire Diagrams

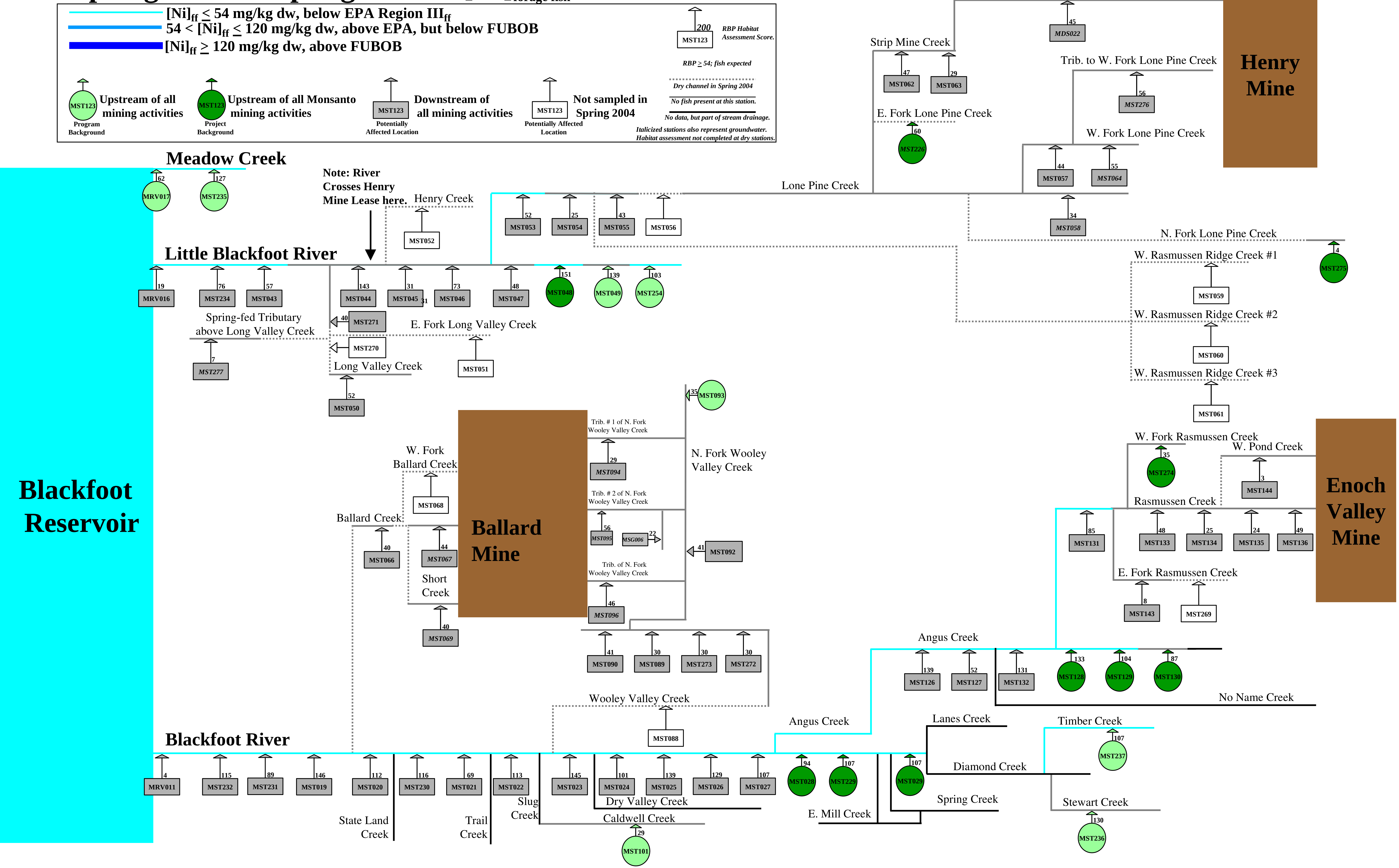
Spring 2004 Sampling Results [Se]$_{\text{forage fish and salmonids}}$



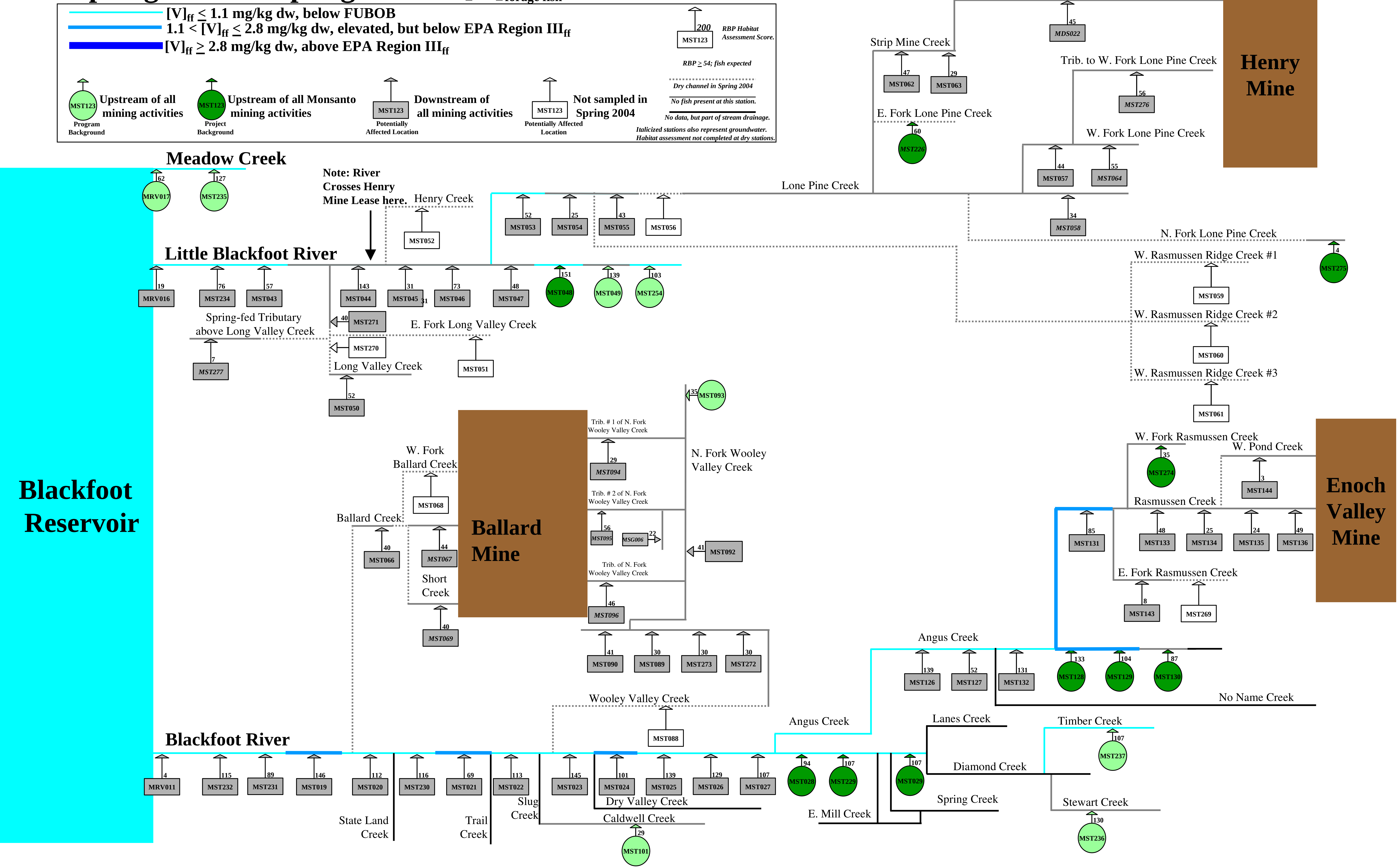
Spring 2004 Sampling Results $[Cd]_{forage\ fish}$



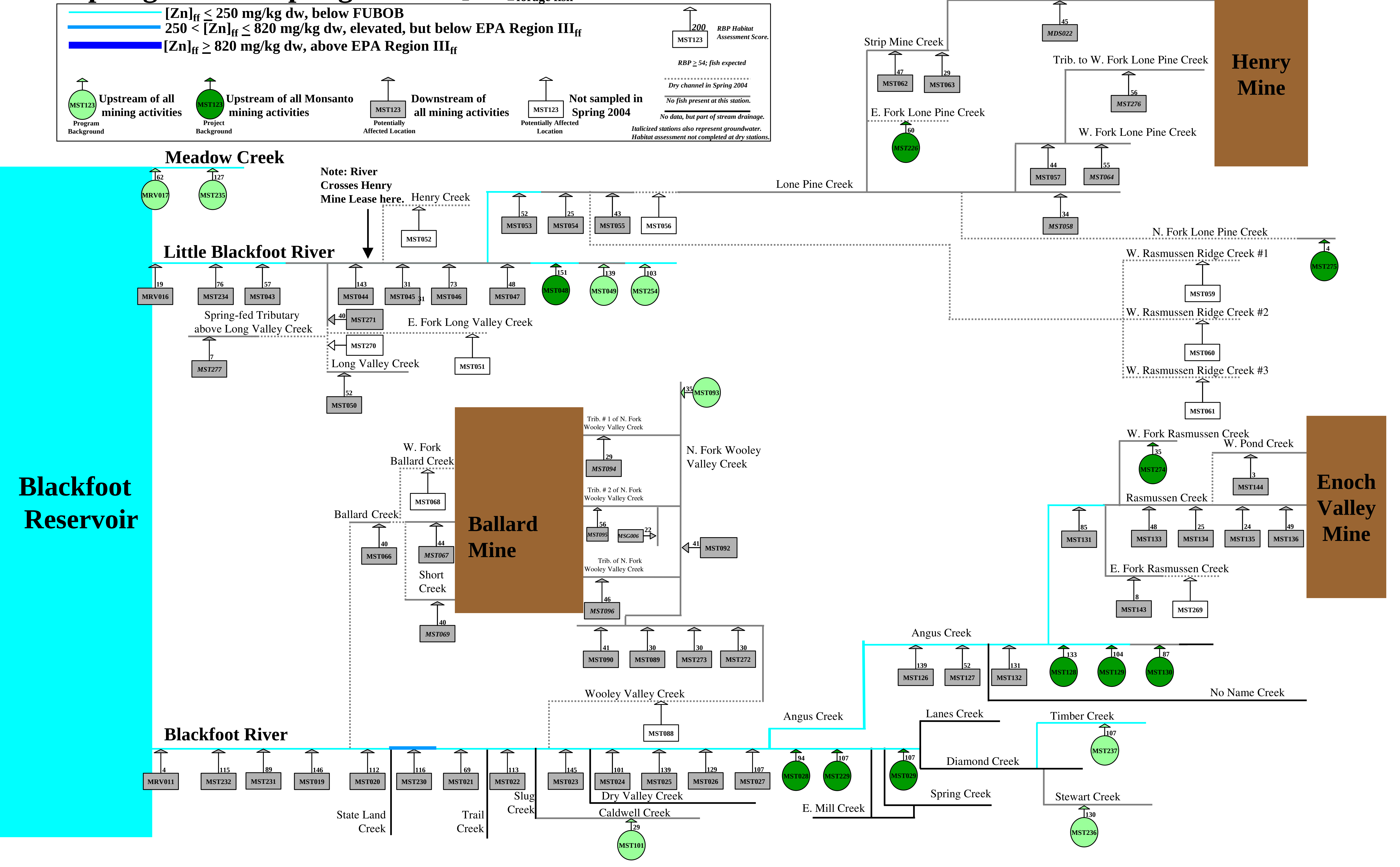
Spring 2004 Sampling Results $[Ni]_{forage\ fish}$



Spring 2004 Sampling Results $[V]_{forage\ fish}$



Spring 2004 Sampling Results $[Zn]_{forage\ fish}$

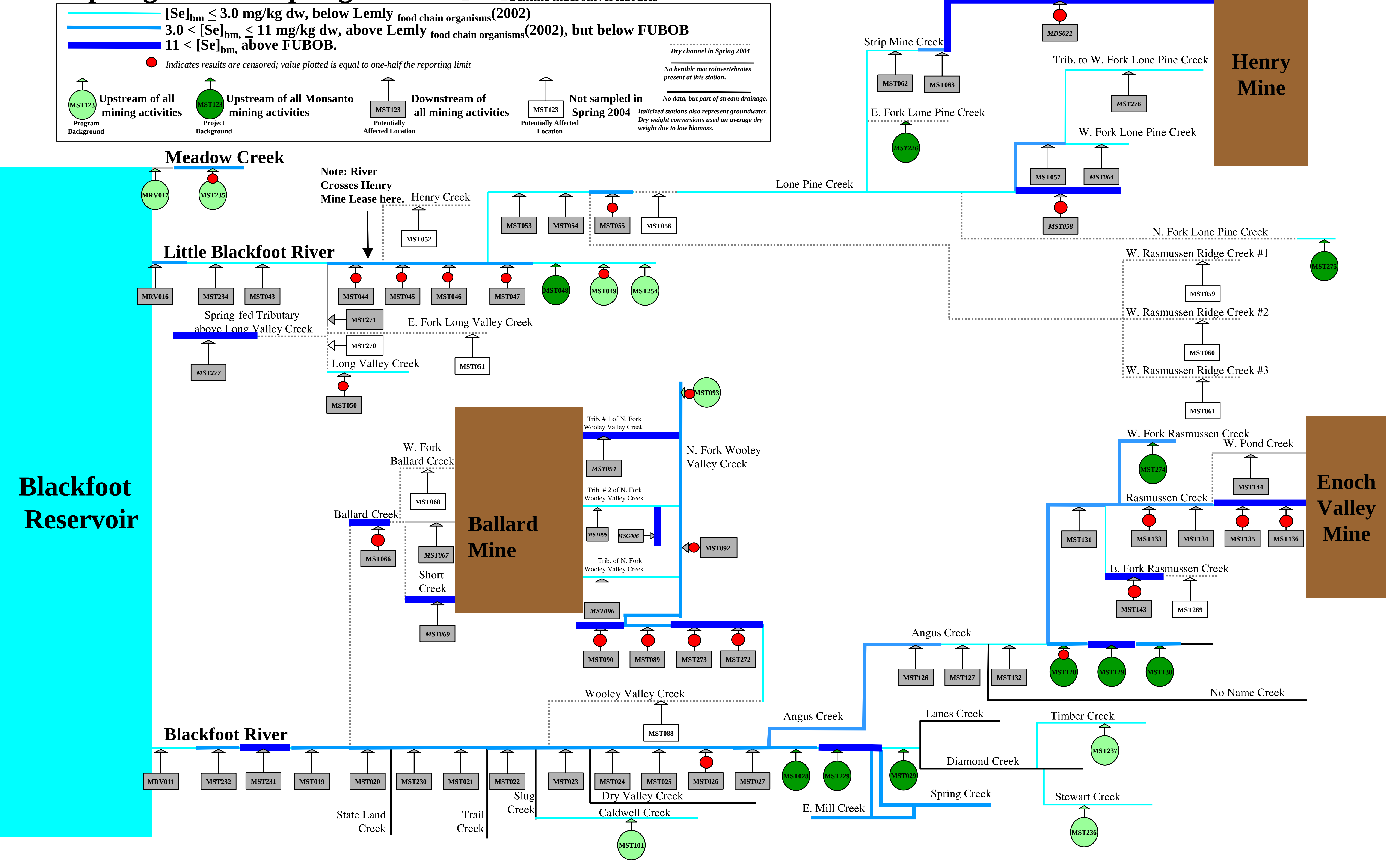


Appendix F
Benthic Macroinvertebrates Spatial Wire Diagrams

Appendix F: Benthic Macroinvertebrate Spatial Wire Diagrams

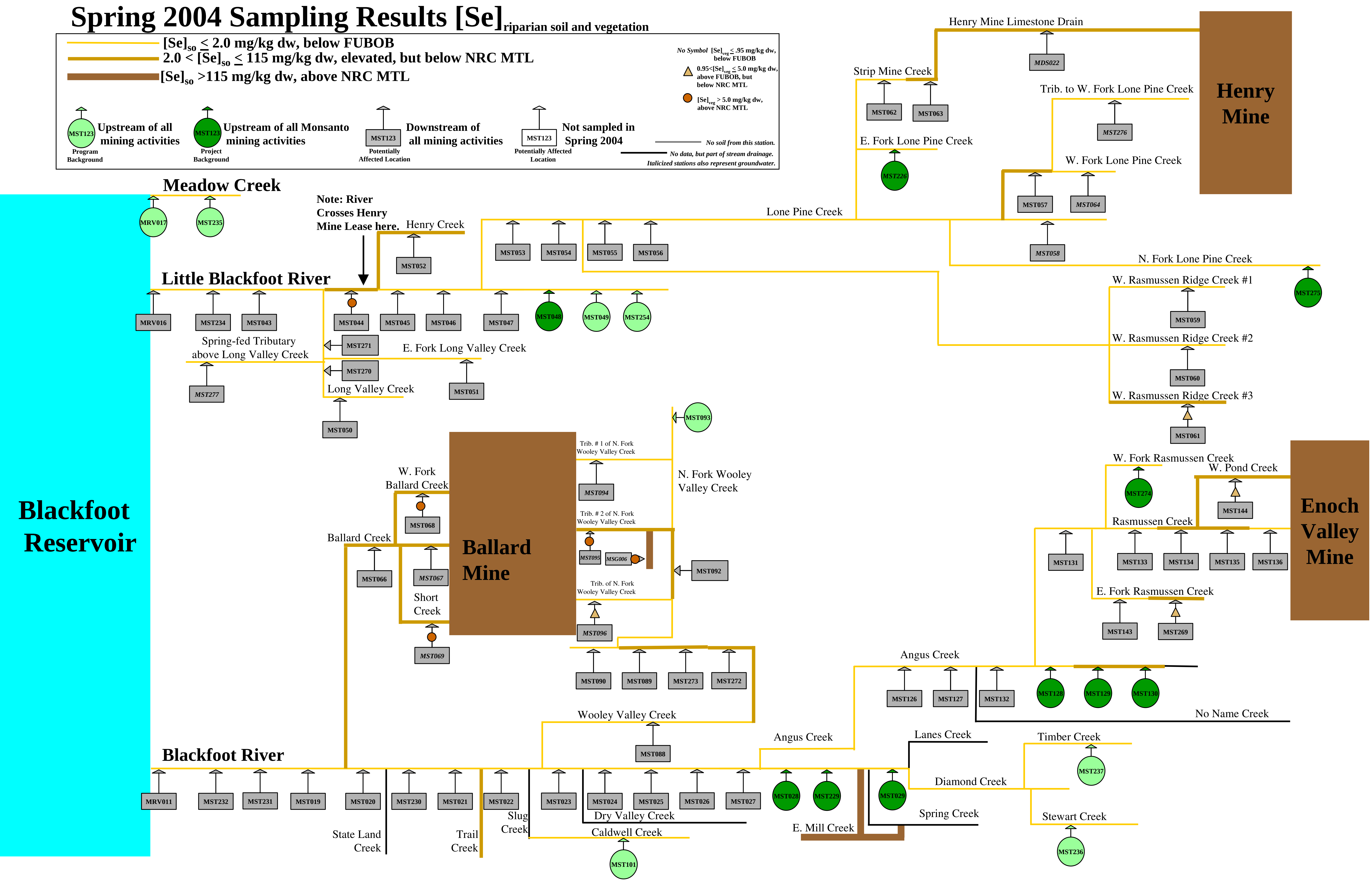
Spring 2004 Sampling Results: Selenium Concentrations in Benthic Macroinvertebrates

Spring 2004 Sampling Results $[Se]_{benthic\ macroinvertebrates}$



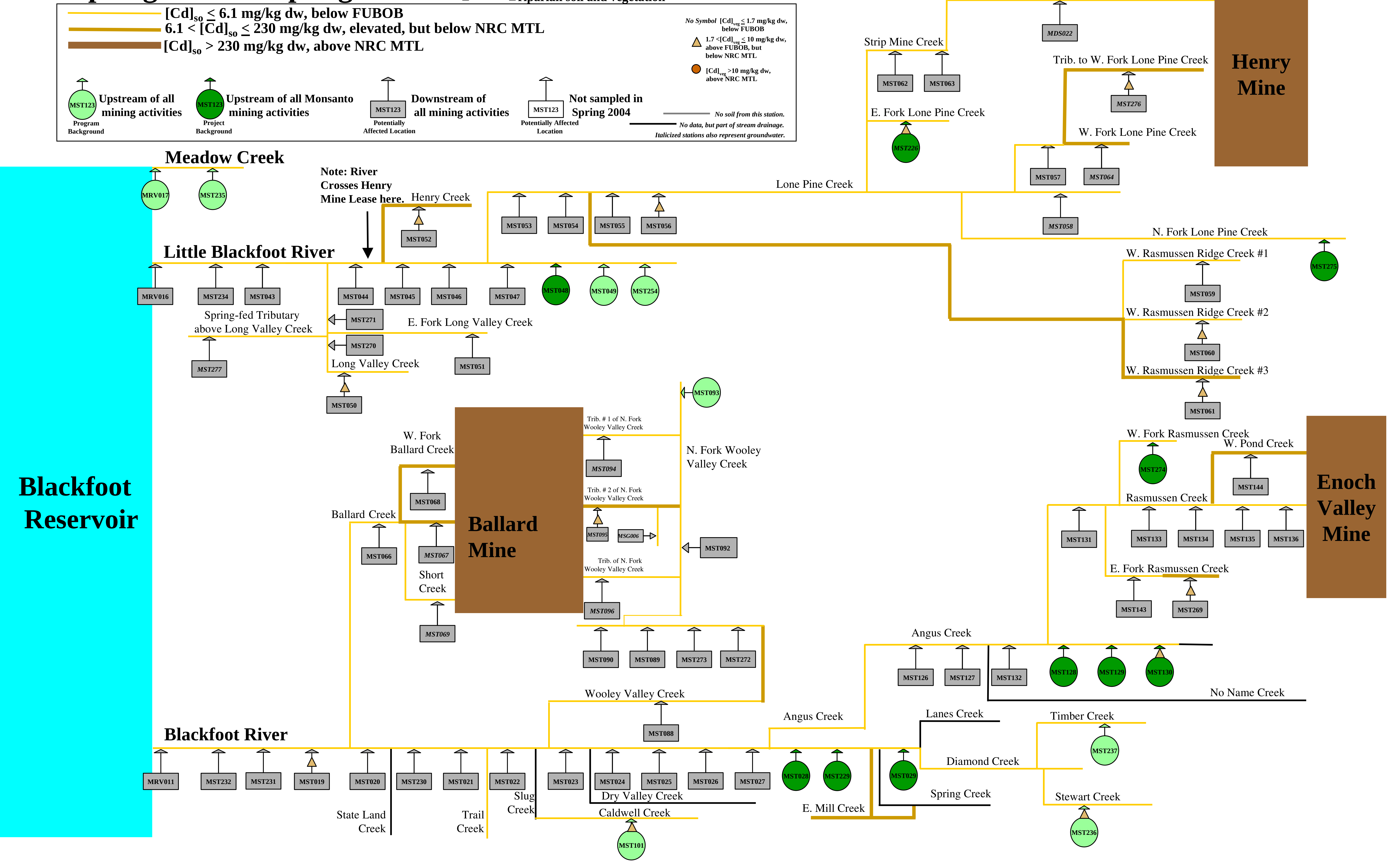
Appendix G
Riparian Soil and Vegetation Spatial Wire Diagrams

Appendix G: Riparian Soil and Vegetation Spatial Wire Diagrams

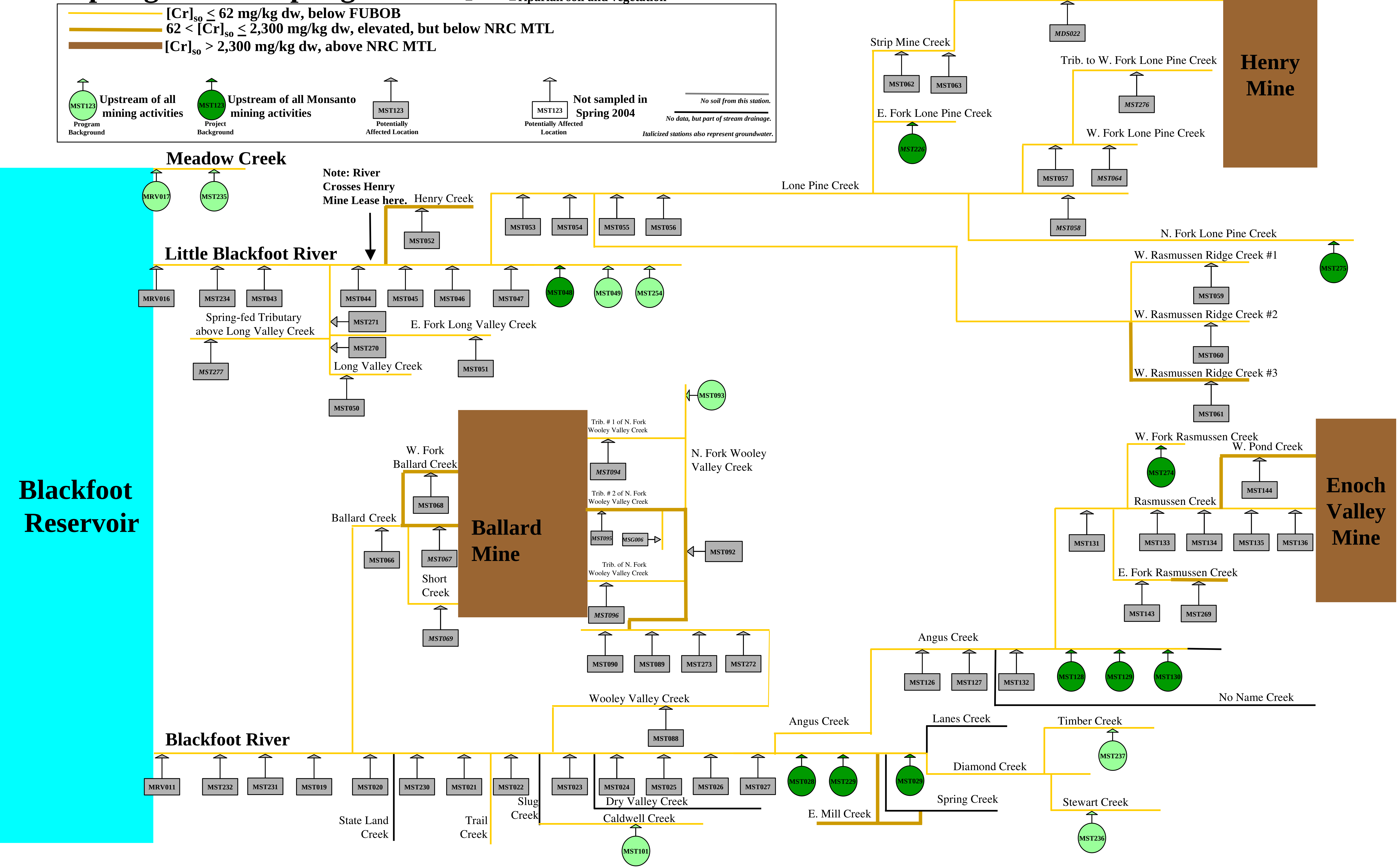


Spring 2004 Sampling Results [Se]riparian soil and vegetation
[Se]so ≤ 2.0 mg/kg dw, below FUBOB
2.0 < [Se]so ≤ 115 mg/kg dw, elevated, but below NRC MTL
[Se]so >115 mg/kg dw, above NRC MTL
No Symbol [Se]veg ≤ .95 mg/kg dw, below FUBOB
0.95<[Se]veg ≤ 5.0 mg/kg dw, above FUBOB, but below NRC MTL
[Se]veg > 5.0 mg/kg dw, above NRC MTL
MST123 Upstream of all mining activities
Program Background
MST123 Upstream of all Monsanto mining activities
Project Background
MST123 Downstream of all mining activities
Potentially Affected Location
MST123 Not sampled in Spring 2004
Potentially Affected Location
No soil from this station.
No data, but part of stream drainage.
Italicized stations also represent groundwater.
Meadow Creek
MRV017
MST235
Note: River Crosses Henry Mine Lease here.
Henry Creek
MST052
Little Blackfoot River
MRV016
MST234
MST043
MST044
MST045
MST046
MST047
MST048
MST049
MST254
Spring-fed Tributary above Long Valley Creek
MST277
MST271
MST270
E. Fork Long Valley Creek
MST051
Long Valley Creek
MST050
MST053
MST054
MST055
MST056
Lone Pine Creek
Henry Mine Limestone Drain
MDS022
Strip Mine Creek
MST062
MST063
E. Fork Lone Pine Creek
MST226
Trib. to W. Fork Lone Pine Creek
MST276
W. Fork Lone Pine Creek
MST057
MST064
MST058
Henry Mine
N. Fork Lone Pine Creek
MST275
W. Rasmussen Ridge Creek #1
MST059
W. Rasmussen Ridge Creek #2
MST060
W. Rasmussen Ridge Creek #3
MST061
Blackfoot Reservoir
MST093
Trib. # 1 of N. Fork Wooley Valley Creek
MST094
N. Fork Wooley Valley Creek
Trib. # 2 of N. Fork Wooley Valley Creek
MST095
MSG006
MST092
Trib. of N. Fork Wooley Valley Creek
MST096
W. Fork Ballard Creek
MST068
Ballard Creek
MST066
MST067
Short Creek
MST069
Ballard Mine
MST090
MST089
MST273
MST272
Wooley Valley Creek
MST088
W. Fork Rasmussen Creek
MST274
W. Pond Creek
MST144
Rasmussen Creek
MST131
MST133
MST134
MST135
MST136
Enoch Valley Mine
E. Fork Rasmussen Creek
MST143
MST269
Angus Creek
MST126
MST127
MST132
MST128
MST129
MST130
No Name Creek
Angus Creek
Lanes Creek
Timber Creek
MST237
Diamond Creek
Stewart Creek
MST236
Blackfoot River
MRV011
MST232
MST231
MST019
MST020
MST230
MST021
MST022
MST023
MST024
MST025
MST026
MST027
MST028
MST229
MST029
State Land Creek
Trail Creek
Slug Creek
Dry Valley Creek
Caldwell Creek
MST101
E. Mill Creek
Spring Creek

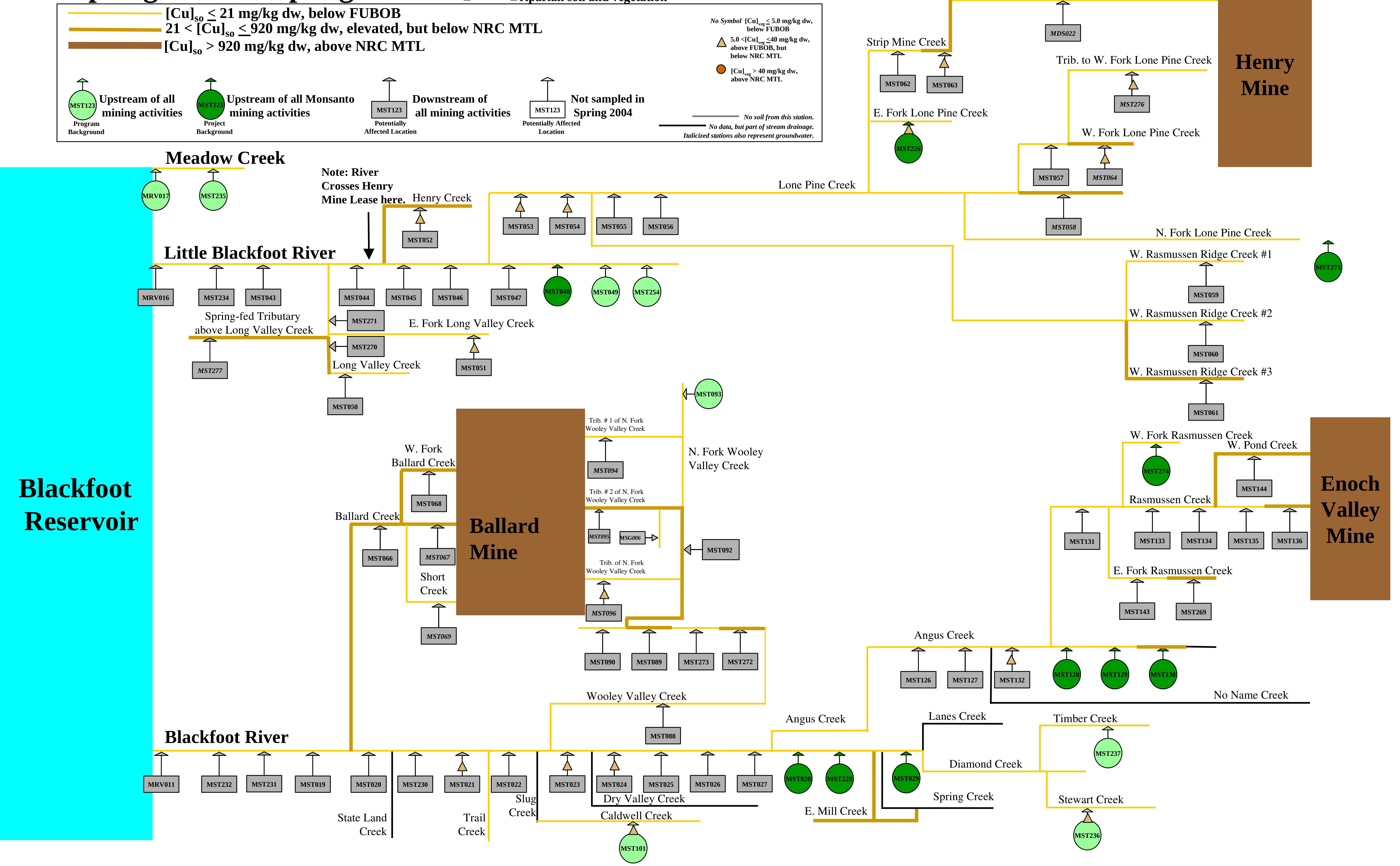
Spring 2004 Sampling Results [Cd]$_{\text{riparian soil and vegetation}}$



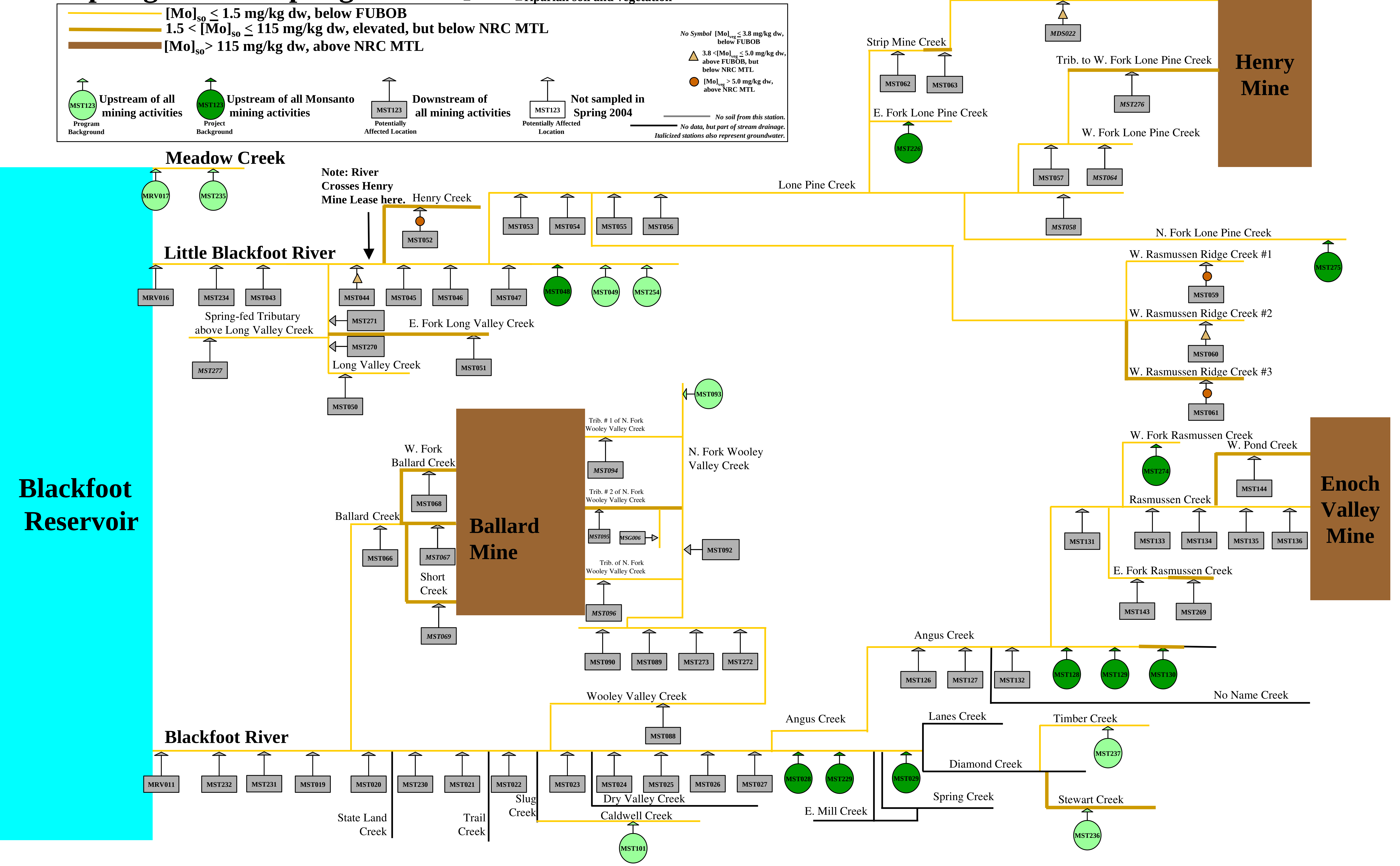
Spring 2004 Sampling Results $[Cr]_{\text{riparian soil and vegetation}}$



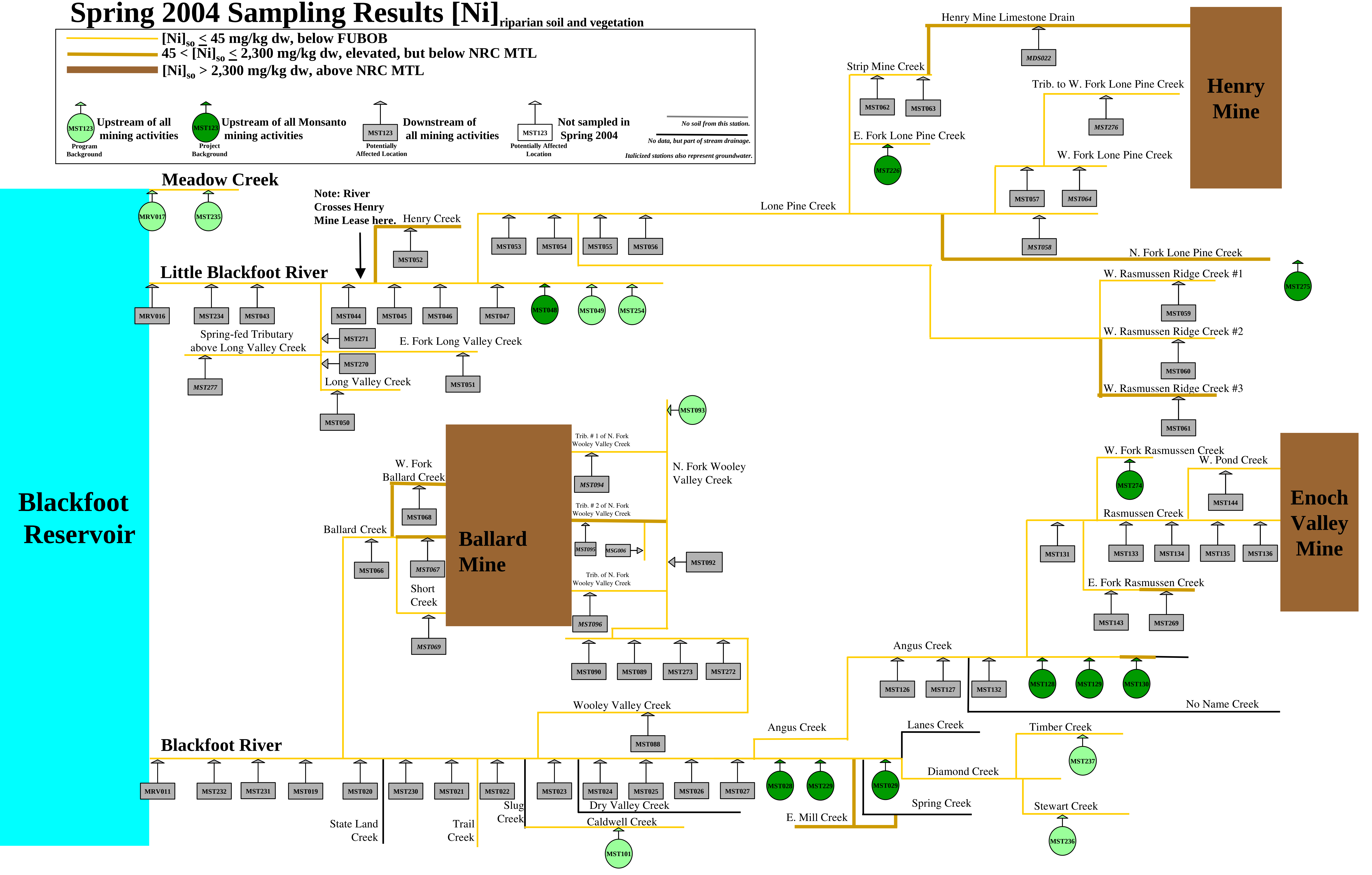
Spring 2004 Sampling Results [Cu]riparian soil and vegetation



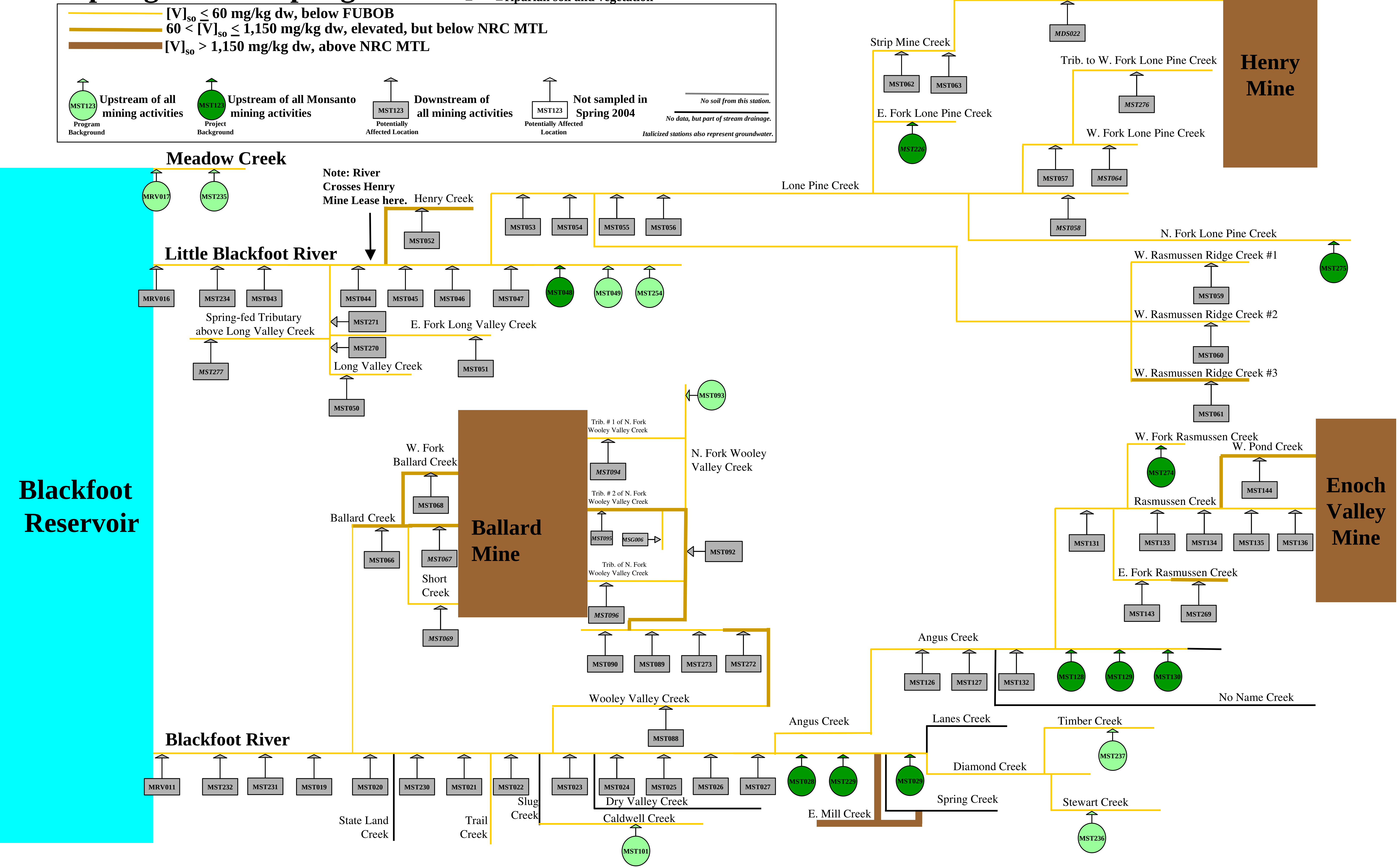
Spring 2004 Sampling Results $[Mo]_{riparian\ soil\ and\ vegetation}$



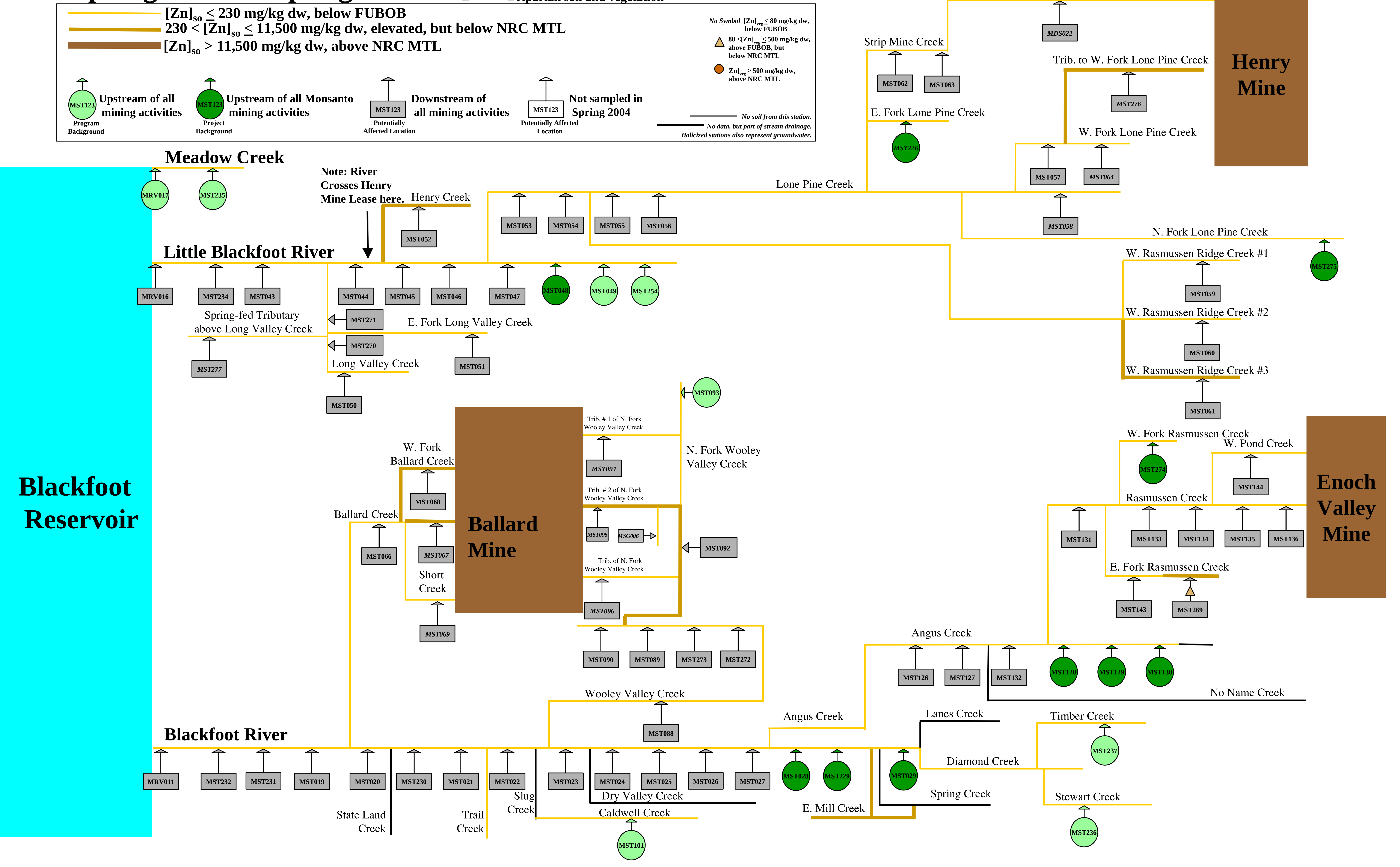
Spring 2004 Sampling Results $[Ni]_{\text{riparian soil and vegetation}}$



Spring 2004 Sampling Results $[V]_{riparian\ soil\ and\ vegetation}$



Spring 2004 Sampling Results $[Zn]_{riparian\ soil\ and\ vegetation}$



Appendix H
SI Seasonal Vegetation Investigation

M E M O R A N D U M

MWH
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Phone: (425) 602-4000
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To: B. Geddes, Monsanto
Date: 6/28/04
From: P. Stenhouse and B. Wright, MWH
Reference: 1010076.011601
Subject: P_4 Production SI Seasonal Vegetation Investigation

This program memorandum serves to provide supplemental guidance and additional data needs information to be made available by May through October, 2004 sampling to be conducted by P_4 Production. It will be included in the final project work plan and programmatic sampling plan binders and will become part of the program record.

This memorandum outlines the additional sampling requested by USFS—to collect vegetation samples at selected waste dumps and riparian zones to supplement existing information. The collection of vegetation samples will be used to provide analytical data to confirm or refute, as they apply to P_4 Production's mines, the notion that selenium concentrations in vegetation is highest during the end of July, as compared to September (considered to be the end of the growing season). These data may also be used to determine if there is a significant relationship between vegetation concentrations and seasonal water levels in the upper Blackfoot River watershed.

Vegetation samples will be collected at one waste dump from each of the three mines, and three Blackfoot River stations, previously located by IMA investigations. See the following table for the list of the stations and their coordinates.

Seasonal Selenium Vegetation Sampling Locations			
Station Number	**Latitude**	**Longitude**	**Location Information**
WD081	N42° 49’ 30.4”	W111° 28’ 59.6”	Ballard Mine Pit #1 Overburden Dump #2
WD086	N42° 52’ 19.9”	W111° 27’ 54.7”	Henry Mine Center Waste Dump
WD091	N42° 52’ 17.9”	W111° 24’ 7.4”	Enoch Valley Mine Waste Dump
MST021	N42° 47’ 24.7”	W111° 28’ 6.0”	Blackfoot River below Trail Creek
MST027	N42° 49’ 42.0”	W111° 20’ 49.0”	Blackfoot River below Angus Creek
MST231	N42° 48’ 35.8”	W111° 33’ 4.4”	Blackfoot River below Woodall Mountain Creek

Notes:

Blackfoot River stations were selected for ease of access, and those containing historically elevated selenium concentrations.

Waste dump locations were selected for ease of access, abundant vegetation, and areas with little or no slope, which are unlikely to be affected by run-on surface water from other portions of the surrounding dump.

Vegetation samples will be collected each month during the growing season, from May 2004 to October 2004. At each station, a 2500 ft^2 quadrat will be placed, (50 ft X 50 ft on waste dumps, and 125 ft X 20 ft at Blackfoot River stations) and a minimum of 5 samples will be randomly collected from each quadrat. Samples collected from each quadrat will consist of the stem and leaf portion of herbaceous forage. ACZ laboratory requests a minimum 200 g for analyses. If the minimum biomass is not reached by the fifth sample, additional samples will be collected until the minimum biomass is acquired. Vegetation samples will be placed in ziploc bags and preserved using wet ice during collection, stored under refrigerated conditions in a locked refrigerator in the field, and preserved with wet ice for shipment to the analytical laboratory. ACZ will store samples at 4° C until selenium analyses. One of the six locations will be selected by field personnel for QA/QC stations.

Vegetation samples will be analyzed by ACZ for total selenium (M7742 Modified, AA-Hydride for vegetation samples, and SM3114 B, AA-Hydride for the equipment and water blank samples associated with the QA/QC station) as well as dry weight. Equipment and water blanks will be analyzed for total selenium only.

Appendix I
SI Benthic Macroinvertebrate Investigation

M E M O R A N D U M

MWH
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To: B. Geddes, Monsanto **Date: 6/21/04**
From: P. Stenhouse and B. Wright, MWH **Reference: 1010076.011601**
Subject: P_4 Production SI Benthic Macroinvertebrate Investigation

This program memorandum serves to provide supplemental guidance and additional data needs information to be provided during the Spring 2004 sampling to be conducted by P_4 Production. It will be included in the final project work plan and programmatic sampling plan binders and will become part of the program record.

This memorandum outlines the additional sampling requested by IDEQ—to collect benthic macroinvertebrates to supplement existing information. The collection of benthic macroinvertebrates will be used to provide analytical data to confirm or refute, as they apply to P_4 Production's mines, proposed toxic effects thresholds published by Lemly. These data may also be used to determine if there is a significant relationship between benthic macroinvertebrate data and other media collected during the same high-flow period, including food-chain effects to resident and migratory fishes.

Collection of benthic macroinvertebrates will be completed using Hester-Dendy samplers. At each fish collection station, three Hester-Dendy samplers will be placed in the stream channel, normal to stream flow and approximately equidistant across the channel, unless the stream channel is narrow (< 10 ft wide), then samplers will be placed in a series within a ~ 25-ft reach (samplers were placed May 19 through 23, 2004). The samplers will be collected during the June 2004 field sampling events, placed in ziploc bags and preserved using wet ice during collection, stored under refrigerated conditions in a locked refrigerator in the field, preserved with wet ice for shipment to the taxonomy laboratory, stored refrigerated in the taxonomy laboratory, then frozen for shipment and storage in the chemical laboratory. The period of incubation for each sampler will be one month.

Benthic macroinvertebrates will be classified to the ordinal level by taxonomists at Chadwick and Associates. Chadwick and Associates will provide counts of Ephemeroptera, Plecoptera, and Trichoptera (EPT) orders for each Hester-Dendy sample, as well as a total count for all other benthic macroinvertebrates not identified as EPT. After such classification and determination of the EPT ratio for each sample, samples will be shipped to ACZ for selenium analyses and dry weight measurement. The University of Idaho will be the quality assurance laboratory, and ACZ will provide them with prepared sample aliquots for each QA station. Samples will be analyzed and data reported uncensored by the laboratories, and MWH will validate these data according to the programmatic Quality Assurance Plan. ACZ will be given authority to combine samples from the same station when the minimum amounts for analysis are not available for a given sample. Any such compositing of samples will follow the decision matrix listed below.

Laboratory Decision Matrix for Compositing Same-Station Samples to Achieve Minimum Analytical Volumes

Scenario	Sample 1	Sample 2	Sample 3	Instruction
Scenario 1	Sufficient Volume	Sufficient Volume	Sufficient Volume	Analyze all three samples separately.
Scenario 2	Sufficient Volume	Sufficient Volume	Insufficient Volume	Analyze Sample 1. Combine Samples 2 & 3 and analyze.
Scenario 3	Sufficient Volume	Insufficient Volume	Insufficient Volume	If Samples 2 and 3 can be combined to attain sufficient volume, combine them and analyze while analyzing Sample 1 separately. If not, composite all three samples and analyze.
Scenario 4	Insufficient Volume	Insufficient Volume	Insufficient Volume	Composite all three and analyze.

Appendix J
Field Investigation Update July 2004 Mass Wasting Sampling Effort

P_4 Production

Mine-specific Site Investigation

Field Investigation Update
July 2004 Mass Wasting Sampling Effort

During the June 2004 field investigation, MWH personnel conducted circum-dump reconnaissance at Ballard, Henry, and Enoch Valley mines, as a precursor to satisfying program objectives 20 and 21 from PgmFSP, Section 3.0.

20. Characterize the change in quality of soil from waste rock dumps onto adjacent rangeland in areas susceptible to mass wasting.

21. Characterize the change in quality of vegetation from waste rock dumps onto adjacent rangeland in areas susceptible to mass wasting.

These objectives are further described as tasks in sections 4.0, and 6.0 of the PgmFSP.

In July, 2004, MWH will conduct one time sampling of waste dumps and native rangeland to support the above program objectives. Three potentially impacted areas, and two background areas will be selected for sampling. The three potentially impacted areas will be preferentially selected such that one area from each mine will be chosen. The two background areas will similarly be selected, such that each location will be placed on separate mines.

MWH field personnel conducted a three day circum-dump reconnaissance from June 14–16th, spending approximately one day at each P_4 mine. At Ballard Mine, six mass wasting areas were identified, and one control area. At Henry Mine, five mass wasting areas were identified, and two control areas. At Enoch Valley Mine, four mass wasting areas were identified, and one control area. Listed below are the location and description of each mass wasting area, grouped by mine.

Ballard Mine

1. MWD084 Ballard Mine Pits #5 and #6 Overburden Dump
   Location: N42° 51' 51", W111° 29' 10"
   High gradient landforms, with a slumping scar at the top of the slope, which is not well healed. Surrounding area is well vegetated. Obvious watercourses are present, flowing downslope, which are well healed and vegetated. A 39° slope in the adjacent, unaffected area, and a 36° slope in area of slump. Area is approximately 250' in width, by 150' high, and semi-circular in nature. Waste dump borders aspen community and terminates at the edge of an aspen stand.

2. MWD084 Ballard Mine Pits #5 and #6 Overburden Dump

Location: N42° 50' 8", W111° 28' 18"
Moderate gradient landforms, with the waste rock slope bisected by a man-made bench, ~30-40' wide. Shales have been washed downhill into native pasture at area of failure, near the lowest portion of bench, and along the outside edge of the waste dump. The terminal margin of the waste dump is difficult to discern due to age of dump and sage/alfalfa mixed community in depositional area. 4° slope in the native pasture area, and 13° slope on the waste dump. Area of washout is ~150' wide (along edge of dump) by 100' deep (from native range/waste dump border inward).

3. MWD082 Ballard Mine Pit #3 Overburden Dump
Location: N42° 49' 34", W111° 28' 18"
High gradient landforms, with rilling, are present at the site. A small pocket of material transport exists at the site. Area is partially vegetated, with limestone cobble near base of waste dump. Area is ~50' along waste dump terminus by 50' deep, extending from dump margin inward and square in nature. Adjacent unaffected slope is 40°. In the area of transport, the slope angle is 42°.

4. MWD082 Ballard Mine Pit #3 Overburden Dump
Location: N42° 49' 33", W111° 28' 13"
High gradient landforms, approximately 250' in width along waste rock dump margin. Old slumping area on the edge of the dump observed. Waste rock is at the angle of repose (~50°) in this area. Area of waste dump is semi-circular in nature, with a slump ~75' wide, and at a 25° slope angle.

5. MWD082 Ballard Mine Pit #3 Overburden Dump
Location: N42° 49' 27", W111° 28' 5"
A possible control location for background characterization at Ballard Mine. Area represented by a flat portion of the dump, which is bordered by native rangeland. Native range slopes uphill from the waste dump. The margin between native range and waste dump is easily discernible.

6. MWD081 Ballard Mine Pit #1 Overburden Dump #2
Location: N42° 49' 23", W111° 29' 20"
High gradient landforms found along waste dump margin. Possible area of slumping. Waste dump slope gradient is 40° above slumped area, and 15° slope angle in the area of the slumping. Rilling and watercourses present on waste dump surface. This is an older area on waste dump, which is well healed over. Native pasture slope angle is 4°, and has been planted for agricultural use.

7. MWD080 Ballard Mine Pit #1 Overburden Dump #1
Location: N42° 50' 12", W111° 29' 3"
Area located on waste dump near Dredge Pond at the north side of waste dump, located on northwest portion of Ballard Mine. Possible slumped area in high gradient landforms. Slumped area is semi-circular in shape, approximately 250' wide, and 75' deep from waste dump margin. The slope angle is divided into an upper and lower slope, 40° and

15°, respectively, in the area of the slumping. This area is well vegetated and covered with grasses. Undisturbed pasture at the edge of the waste dump has a slope angle of 4°.

Henry Mine

1. MWD085 Henry Mine North Pit Overburden Dump
Location: N42° 54' 36", W111° 30' 34"
Possible control area, such that the waste dump has a slope angle of 1°, leading to native range, which has an upslope of 20° at the margin of the waste dump.

2. MWD088 Henry Mine Center Pit #2 Overburden Dump
Location: N42° 53' 48", W111° 29' 29"
High gradient waste dump at the edge of mixed conifer/aspen community along the southern edge. Lower margin of waste dump bordered by sage community. Waste dump has areas of rilling. Waste dump is well vegetated and has grasses and alfalfa present. Slope angle of the waste dump is 31°. Slope angle of native range directly below waste dump is 21°.

3. MWD088 Henry Mine Center Pit #2 Overburden Dump
Location: N42° 53' 43", W111° 28' 52"
Small area on waste dump with minimal slumping that is mostly healed. The area is approximately 150' wide and 50' deep. Waste dump vegetation is alfalfa and grasses. Minimal exposures of shales present on surface of dump, with abundant topsoil. Native vegetation community is dominated by sage and mixed grasses.

4. MWD086 Henry Mine Center Pit #1 Overburden Dump
Location: N 42° 52' 47", W111° 27' 59"
Possible material transport area, including a high gradient slope, with patches of bare soil and shale, and obvious rilling on the waste dump. Vegetation is dominated by grasses and alfalfa. Area of ponding at the terminal margin of waste dump with few cobble/boulder size chert and shale rocks in and along pond. Native range vegetation is a sage/grass mixture. Waste dump slope angle is 34°, and the native range has an upslope of 3°.

5. MWD086 Henry Mine Center Pit #1 Overburden Dump
Location: N42° 52' 53", W111° 27' 17"
Possible control area, waste dump has moderate slope down to terminus of dump. Native range upslope is ~20-30°. Waste dump is well vegetated with alfalfa and some grasses. Native range vegetation consists of sage brush, other short shrubs and grasses.

6. MWD087 Henry Mine Center Pit #1 Canyon Fill Dump
Location: N42° 52' 17", W111° 28' 40"
Possible mass wasting area at the bottom of the canyon fill dump. Some rilling present, especially along the margin between native range and waste dump. The waste dump is

vegetated with grasses and sparse wild rye. Native range is vegetation is a sage/grass mixed community.

7. MWD090 Henry Mine South Pit Overburden Dump
Location: N42° 51’ 54”, W111° 26’ 58”
Waste dump slope is uneven, indicative of possible downhill transport, but no real obvious rilling or large slumps. Waste dump vegetation community comprised of alfalfa and grasses. Native vegetation consists of sage and grasses. Waste dump is intersected by a lift. The waste dump slope angle is 26°, and the native range slope angle is 7°.

Enoch Valley Mine

1. MWD091 Enoch Valley Mine Waste Dump
Location: N42° 53’ 34”, W111° 25’ 46”
Some past evidence of rilling present on waste rock dump surface. Waste dump vegetation dominated by grasses. The slope angle of the native range is 22°. The waste dump slope has two separate angles. The lower portion of the waste dump, which borders native range is 16° and the waste dump slope angle above is 26°.

2. MWD091 Enoch Valley Mine Waste Dump
Location: N42° 53’ 49”, W111° 26’ 0”
This area is located at the northern end of the Enoch Valley Mine. Some small rilling, as well as a potential for mass wasting. Vegetative cover on dump is composed of alfalfa and grasses. Native range is mainly grass. Slope angle on waste dump is 21°. Native range slope is 10°. An artificially constructed berm is located along one side of area, as well as a bench in the waste rock slope. These two features will direct water towards a single drainage point.

3. MWD091 Enoch Valley Mine Waste Dump
Location: N42° 52’ 52”, W111° 24’ 19”
Semi-circular shape in the waste rock dump, which may transport material downslope. Difficult to discern because the area is almost completely healed. Waste dump vegetation is comprised of grasses and some alfalfa. Native range supports an aspen forest, with some conifers. Grasses present in the understory. Area is ~75’ wide and 50’ deep. Waste dump slope angle is 23°. Native range slope angle is 13°.

4. MWD091 Enoch Valley Mine Waste Dump
Location: N42° 52’ 34”, W111° 24’ 37”
Semi-circular shape along waste dump terminus. Vegetation on waste dump is dominated by grasses with some alfalfa and minimal flowering plants. Native range vegetation is comprised of grasses and sparse sage. Waste dump slope has two angles, indicative of a previous failure. The lower slope angle is 7°, and the upper slope angle is 23°. The native range slope angle is 5°.

5. MWD091 Enoch Valley Mine Waste Dump

Location: N42° 51’ 56”, W111° 23’ 48”
Possible control area located on the southern portion of the dump. Area is shaped by a V-notch, with a road at the base of the V, and on waste dump. Waste dump vegetation consists primarily of grasses and wild rye. Some exposed shales are also present. Exposed bedrock is present in the native range, with sage and grass vegetation community. The waste dump slope angle is 19°. The native range has an upslope of 13° away from the road surface.

Using random selection, the following locations have been selected for sampling during the July 2004 sampling event, which includes soil and vegetation at the selected sites.

<u>Impacted Areas</u>
Ballard Mine #3
Henry Mine #4
Enoch Valley Mine #1

<u>Control Areas</u>
Henry Mine #1
Enoch Valley Mine #5

Appendix K
Medium Specific Data and Data Gap Summaries

Overall Site Investigation Objectives

The remedial investigation and feasibility study (RI/FS) process…represents the methodology that the Superfund program has established for characterizing the nature and extent of risks posed by uncontrolled hazardous waste sites and for evaluating potential remedial options. This approach should be viewed as a dynamic, flexible process that can and should be tailored to specific circumstances of individual sites; it is not a rigid step-by-step approach that must be conducted identically at every site. The project manager's central responsibility is to determine how best to use the flexibility built into the process to conduct an efficient and effective RI/FS that achieves high quality results in a timely and cost-effective manner. A significant challenge project managers face in effectively managing an RI/FS is the inherent uncertainties associated with the remediation of uncontrolled hazardous waste sites. These uncertainties can be numerous…. While these uncertainties foster a natural desire to want to know more, this desire competes with the Superfund program's mandate to perform cleanups within designated schedules.

The objective of the RI/FS process is not the unobtainable goal of removing *all* uncertainty, but rather to gather information sufficient to support an informed risk management decision regarding which remedy appears to most appropriate for a given site.

USEPA, 1998, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final*, Office of Emergency and Remedial Response, Washington, DC.

As a general objective, the data collection process is to provide those data that are necessary to evaluate among and select a removal action alternative in the EE/CA process. The amount of such data to be collected will be what is sufficient to conduct such evaluation and selection.

P4 Production, 2004, *Comprehensive Site Investigation Ballard Mine Work Plan—Final*, MWH, Bellevue, WA.
P4 Production, 2004, *Comprehensive Site Investigation Henry Mine Work Plan—Final*, MWH, Bellevue, WA.
P4 Production, 2004, *Comprehensive Site Investigation Enoch Valley Mine Work Plan—Final*, MWH, Bellevue, WA.

Media: Surface Water and Sediment

Scope of Work

<u>Interim Surface Water and Sediment Investigation</u>

- Task 1—Comprehensive Surface Water and Sediment Sampling
- Task 3—Selenium and Chromium Speciation
- Task 4—High-Resolution Seasonal Sampling
- Task 5—Low-Resolution Seasonal Sampling

<u>Site Investigation, Task 1—Surface Water and Sediment Investigation</u>

- Subtask 1a—Investigation of Historic Irrigation Practices
- Subtask 1b—Surface Water and Sediment Sampling
  - Activity 1b-1—Impacted riparian zones
  - Activity 1b-2—Fish tissue quality investigation

Objectives

- Quantify seasonal temporal variability in water and sediment quality in stock ponds, dumps seeps, and streams.
- Quantify annual temporal variability in water and sediment quality in stock ponds, dumps seeps, and streams.
- Identify water bodies or, as appropriate, portions of water bodies that have contaminated surface water, i.e., those that contain elevated concentrations of selenium relative to those observed in background or control samples, which range up to approximately 0.002 mg/L. Identify those contaminated water bodies or, as appropriate, portions of contaminated water bodies that are out of compliance with the state's selenium chronic cold-water biota standard of 0.005 mg/L. Identify those out-of-compliance water bodies or, as appropriate, portions of out-of-compliance water bodies that have selenium surface-water concentrations that pose an unacceptable threat to human or environmental health, which is anticipated to be in the range of 0.005 to 0.05 mg/L, where the latter is the human drinking water standard and a veterinary benchmark often used for livestock drinking water. Also, identify those water bodies or, as appropriate, portions of water bodies that are not contaminated.
- Identify water bodies or, as appropriate, portions of water bodies that have contaminated sediment, i.e., those that contain elevated concentrations of selenium relative to those observed in background or control samples, which range up to approximately 4 mg/kg dw. Identify those contaminated water bodies or, as appropriate, portions of contaminated water bodies that have selenium sediment concentrations that pose an unacceptable threat to human or environmental health, which is anticipated to be at a concentration in excess of background levels.
- Characterize mine-specific and district-specific background water and sediment quality.
- Characterize, indirectly, groundwater quality to focus subsequent hydrogeological investigation.
- Characterize the general nature of the speciation of selenium and chromium.
- Statistically evaluate mine-specific impacts using longitudinal profiles and regression techniques or paired up- and down-stream stations with analysis of variance and multiple comparison (with an experimentwise-controlled error rate) techniques.
- Obtain high-quality flow measurements in streams to allow conversion of concentration (mg/L) to the more meaningful flux (L/s), the only effective way in which to evaluate longitudinal profiles.
- Determine if there are any past or current irrigation canals that could affect water flow on or near the mines.
- Characterize surface water and sediment quality to support characterization of riparian soil and vegetation quality and fish tissue quality, as well as to further quantify annual variability.

Investigation Effort

- Sampling events—31
- Stations—125
- Samples—1,500
- Analyses—35,000.

Conceptual Model

- Source—Selenium from interburden found primarily in external waste rock dumps. Some additional contaminants in ponds on interburden and in seeps. The direct source for surface water is groundwater. The direct source for sediment is waste rock.
- Release mechanism—Fragmentation of interburden and exposure to air results in oxidation of reduced selenium on increased surface areas; precipitation leaches and mobilizes such oxidized surficial selenium primarily during spring runoff.
- Exposure pathways—Shallow alluvial and colluvial transport with discharge to streams via seeps. Elevated sediment selenium confined to ponds on interburden and seeps in or adjacent to waste rock dumps.
- Receptors—Yellowstone cutthroat trout in fish-bearing streams. Livestock drinking from seeps or ponds on or adjacent to interburden.

Discussion

The spatial extent of selenium contamination is well defined through a network of about 125 sampling stations. Wire concentration and loading diagrams show that none of Monsanto's three historic mines is providing a significant amount of selenium to fish-bearing waters. Sediment contamination is restricted to those stations (ponds and seeps) where the seleniferous sediment contains waste rock.

The temporal extent of selenium contamination is well defined seasonally and more than sufficient information exists to characterize year-to-year variability. The potential for any significant downstream migration of elevated selenium concentrations is limited to the period of spring runoff. This seasonal pattern indicates that the source of surface water contamination is shallow, alluvial and colluvial groundwaters closely associated with surface drainage features.

Data Gaps

For purposes of commencing an EE/CA, there are no data gaps for surface water or sediment. Sampling is currently planned for fall 2007 and spring and fall 2008; however, these sampling events are superfluous in light of the six years of data that are already available for the AOC-defined contaminants of potential concern and at many stations. Should data gaps be identified for related media (e.g., fish or riparian vegetation), additional sampling of surface water and sediment would likely make sense—to support the further characterization of the related medium in question.

Media: Geology and Groundwater

Scope of Work

Subtask 3a—Phase I Investigation

Activity 3a-1—Review Available Hydrogeologic Information
Activity 3a-2—Well Inventory
Activity 3a-3—Spring and Seep Survey
Activity 3a-4—Spring and Dump Seep Flow Characterization
Activity 3a-5—Sampling Existing Mine and Domestic Wells, Springs, and Seeps
Activity 3a-6—Revise Conceptual Hydrogeologic Site Model

Subtask 3b—Phase II Investigation

Activity 3b-1—Aerial Mapping of Ballard Mine
Activity 3b-2—Focused Investigation of Existing Wells
Activity 3b-3—Existing Well Sampling and Groundwater Level Monitoring
Activity 3b-4—Revise Conceptual Hydrogeologic Site Model
Activity 3b-5—Preparation of a Technical Memorandum for Monitoring Well Installations
Activity 3b-6—Develop Selenium Attenuation Conceptual Model

Objectives

- Compile and review available local and regional hydrogeologic data—e.g., published and unpublished hydrogeologic reports, geologic maps, cross sections, mine maps, and anecdotal information from mine geologists and managers—so as to make maximum use of such information.
- Conduct a thorough well inventory within a three-mile radius of the mine to document locations and construction specifications of all mine production, agricultural, and domestic wells that could be relevant groundwater sampling stations.
- Conduct a spring and seep survey on the mine and within the vicinity during runoff to identify any additional surface expressions of groundwater for characterization.
- Measure flows of springs and dump seeps during runoff. For dump seeps the purpose is to evaluate alternatives. For springs the purpose is to characterize the nature of the aquifer and thus must occur over time to determine whether flows are continuous or seasonal.
- Sample all relevant groundwater stations—including existing wells, springs, and seeps—for characterization of groundwater quality.
- Update site maps.
- Attempt to learn more about construction details of existing wells.
- Continue to sample wells and surface expressions of groundwater to better characterize seasonal and year-to-year variability in water quality.
- Install additional wells, if necessary, to address data gaps related to identified flow paths associated with potential sources, or possibly to confirm critical components of the updated conceptual hydrogeologic site model.
- Identify potential selenium attenuation mechanisms to help direct potential additional characterization efforts to better describe fate and transport.

Investigation Effort

- Sampling events—27
- Stations—56
- Samples—400
- Analyses—10,000.

Conceptual Model

- Source—Selenium from interburden found primarily in external waste rock dumps. Some additional contaminants in interburden seeps.
- Release mechanism—Fragmentation of interburden and exposure to air results in oxidation of reduced selenium on increased surface areas; precipitation leaches and mobilizes such oxidized surficial selenium primarily during spring runoff.
- Exposure pathways—Shallow alluvial and colluvial transport with discharge to streams via seeps. No impacts to existing domestic, agricultural, or mine production wells located within three miles of any of the historic mines.
- Receptors—Yellowstone cutthroat trout in fish-bearing streams. Livestock drinking surface expressions of groundwater in the forms of seeps or ponds on or adjacent to interburden.

Discussion

No existing wells exceed any drinking water standard, but waste rock dump seeps do for selenium and other target analytes. Selenium is, by far, the contaminant of most concern. The construction of existing wells is such that unfiltered samples are not representative of groundwater quality.

The spatial extent of selenium contamination appears to be rather shallow—i.e., the primary transport pathway appears to be interflow through alluvial and colluvial deposits closely associated with surface drainage features. None of Monsanto's historic mines contributes a significant load of selenium to any of the downstream, fish-bearing surface waters.

The temporal extent of selenium contamination does not appear to vary appreciably by season in a qualitative manner in seeps and most existing wells; however, some seeps, and presumably the associated shallow groundwater flow systems, do ebb in terms of flow volume after spring runoff and some even dry up. This observation corresponds well with the seasonal pattern of contamination seen in surface water. Sufficient information should be available upon completion of the second phase of the investigation to adequately characterize year-to-year variability.

Because of the shallow nature of the groundwater contamination, the network of surface water stations serves to effectively delineate the extent of contamination in this medium, too. Significant transport of selenium in deep groundwater is not likely as reduction and precipitation is expected to remove the selenium from the biosphere in anoxic conditions.

Data Gaps

For purposes of commencing an EE/CA, data gaps exist regarding whether certain groundwater flow paths downgradient from mines are operational in the sense of transporting a sufficient mass of selenium to significantly impact surface water or of containing a concentration in excess of groundwater standards (which are, in turn, derived from drinking water standards). The second phase of the investigation is proceeding to determine whether these flow paths are operational.

Sampling is currently planned for fall 2007 and spring and fall 2008. Wells are being installed this summer, and we anticipate more being installed in 2008 after evaluating data collected in 2007.

Medium: Soil

Scope of Work
<u>Site Investigation, Task 4—Soil Investigation</u>
Subtask 4a—Water Balance
Subtask 4b—Characterization of Extent of Riparian Zone Soil Contamination at Streams, Ponds, Seeps, Springs, and Wetlands
Subtask 4c—Characterization of Waste Rock Dump Extent of Soil Contamination
Subtask 4d—Agronomic Testing of Unreclaimed, Poorly Reclaimed, and Well Reclaimed Land (at Ballard Mine)

Objectives
- Conduct water balances to help understand the hydrologic system of the mines.
- Characterize the quality of riparian zone soil at streams, ponds, seeps, springs, and wetlands, and determine extent of contamination in such habitat soils.
- Characterize the change in quality of soil from waste rock dumps onto adjacent rangeland in areas susceptible to mass wasting.
- Conduct agronomic soil testing on unreclaimed, poorly reclaimed, and well reclaimed land on waste rock piles to evaluate potential reclamation alternatives at Ballard Mine.

Investigation Effort
- Sampling events—7
- Stations—350
- Samples—490
- Analyses—10,000.

Conceptual Model
- Source—Selenium from interburden and overburden found primarily in waste rock dumps.
- Release mechanism—Fragmentation of interburden and exposure to air results in oxidation of reduced selenium on increased surface areas; precipitation leaches and mobilizes such oxidized surficial selenium primarily during spring runoff.
- Exposure pathways—Plant uptake of selenium in the oxidized soil on the surface of waste rock dumps. Shallow alluvial and colluvial transport with discharge to streams via seeps and uptake of selenium by absorber and accumulator plant species on or adjacent to. Primary exposure through ingestion.
- Receptors—Livestock and wildlife ingestion of seleniferous vegetation or soil during grazing.

Discussion

Spatially, the majority of riparian soil samples show no exceedences of chemical thresholds. Few places have elevated concentrations (one above NRC MTL, few above background) of selenium in riparian soil. Upland soils, constituting both impacted and background classifications show abundant selenium sources in waste rock piles, but limited selenium in background Phosphoria outcrops. Selenium transport outside waste rock boundaries is evident in those waste rock piles which remain at or near the angle of repose.

The temporal extent of selenium contamination does not appear to vary appreciably by season in a qualitative manner in upland soils. Long-term reducing trends in selenium sources are not evident.

Data Gaps

The upland and riparian surface and subsurface soil sampling efforts to date are sufficient to understand the nature and extent of any risk associated with contamination in soils. If identifying waste rock dump boundaries is deemed necessary, have a geologist conduct a geo-reconnaissance of waste rock dumps to delineate areas of dump wastage.

Media: Aquatic Ecology

Scope of Work

Site Investigation, Task 5—Aquatic Ecological Investigation

Subtask 5a—Stream Habitat Assessment

Subtask 5b—Fish Tissue Quality Investigation

Objectives

- Develop a predictive model differentiating stream habitat that supports fish from stream habitat that does not support fish.
- Evaluate fish tissue quality against screening benchmarks. Fish tissue results presented spatially for visual (qualitative) comparison.

Investigation Effort

- Sampling events—15
- Stations—130
- Samples—550
- Analyses—2,300.

Conceptual Model

- Source—Selenium from interburden and overburden found primarily in waste rock dumps. The direct source for sediment is waste rock.
- Release mechanism—Fragmentation of interburden and exposure to air results in oxidation of reduced selenium on increased surface areas; precipitation leaches and mobilizes such oxidized surficial selenium primarily during spring runoff.
- Exposure pathways—Shallow alluvial and colluvial transport with discharge to streams via seeps. Elevated sediment selenium confined to ponds on interburden and seeps in or adjacent to waste rock dumps.
- Receptors—Yellowstone cutthroat trout in fish-bearing streams.

Discussion

Spatially, the USEPA Rapid Bioassessment Protocol for high-gradient streams was used consistently across the lotic Monsanto network. The results of which, were used for regression modeling and to determine bright line scoring of aquatic systems. Fish tissue results indicated excess concentrations in the Blackfoot River which were above the USEPA Region III. No fish exceeded 13 mg/kg dw tissue concentration of selenium, consistent with cutthroat studies done by the University of Idaho. Many smaller streams either did not bear fish, or contained fish with acceptable selenium levels.

The temporal extent of selenium contamination is moderately well defined seasonally. The migration movements of fishes in the Blackfoot Reservoir and upper Blackfoot River are well understood. Sampling events were designed to collect information on fish life cycle movements as part of the overall investigation. Two spring and two fall events present information on selenium concentrations in fish tissues. In general, fish are easier to collect in fall, but may have lower tissue concentrations when compared to spring runoff conditions.

The habitat assessment results are sufficient to characterize fish-bearing streams in the current drainage network. The collection of fish tissue data is sufficient to remove enough uncertainty surrounding fish tissue concentrations in the upper Blackfoot River watershed. The drought conditions (and low water levels in the upper Blackfoot River watershed) experienced in SE Idaho during the years of 1999-2005 produced the greatest adverse effect to fish populations in the upper Blackfoot River watershed.

Data Gaps

Conduct in-field confirmation of the fish habitat assessment model, developed based upon 2004 SI data and the USEPA Rapid Bioassessment Protocol (RBP), by conducting another field event using non-lethal sampling techniques.

Media: Terrestrial Ecology

Scope of Work
Site Investigation, Task 6—Terrestrial Ecological Investigation
Subtask 6a—Habitat assessment of ponds, wetlands, and non fish-bearing streams
Subtask 6b—Characterization of extent of riparian zone vegetation contamination at streams, ponds, seeps, springs, and wetlands
Subtask 6c—Evaluate potential replacements for alfalfa in reclamation seed mix
Subtask 6d—Identification and location of known selenium absorber species
Subtask 6e—Veterinary toxicology panel on livestock utilization of reclaimed land
Subtask 6f—Characterization of waste rock dump extent of vegetation contamination
Subtask 6g—Performance monitoring of non-seleniferous cap

Objectives
- Characterize surface water and sediment quality to support the characterization of riparian soil and vegetation quality and fish tissue quality, as well as to further quantify annual variability.
- Compile local and regional climatologic data that may be pertinent to the characterization of annual and seasonal changes in runoff.
- Characterize the quality of riparian zone soil at streams, ponds, seeps, springs, and wetlands.
- A habitat assessment of ponds, wetlands, and non-fish-bearing streams is needed to determine utilization by wildlife, livestock, and birds.
- Characterize the riparian zone vegetation quality to determine the extent of contamination in this habitat along streams, ponds, seeps, springs, and other wetlands.
- Evaluate a suitable seed mixture that provides desirable traits for reclamation—erosion control, cover, and future grazing potential.
- Incorporate asters into their weed control program, identify the locations of their occurrences on Enoch Valley Mine, and begin to control them.
- Formation of a veterinary toxicology panel to review existing information on livestock exposure to seleniferous vegetation on waste rock dumps.
- Compile existing mine maps to be used in the EE/CA process to evaluate certain alternatives.
- Characterize the change in quality of vegetation from waste rock dumps onto adjacent rangeland in areas susceptible to mass wasting.
- Monitor the performance of the non-seleniferous cap at Enoch Valley to isolate seleniferous shales from the root zone.

Investigation Effort
- Sampling events—27
- Stations—510
- Samples—2,400
- Analyses—22,000.

Conceptual Model
- Source—Selenium from interburden and overburden found primarily in waste rock dumps. Some additional contaminants in stock ponds on interburden and in seeps. The direct source for surface water is groundwater. The direct source for sediment is waste rock.
- Release mechanism—Fragmentation of interburden and exposure to air results in oxidation of reduced selenium on increased surface areas; precipitation leaches and mobilizes oxidized surficial selenium primarily during spring runoff.
- Exposure pathways—Shallow alluvial and colluvial transport with discharge to streams via seeps. Ingestion of seleniferious vegetation.
- Receptors—Birds, livestock, and elk ingesting seleniferous material.

Discussion

The spatial extent of selenium contamination in the terrestrial ecosystem is well defined. The habitat quality of ponds, wetlands, and non-fish bearing streams is highly dependent upon habitat quality and less dependent on selenium concentrations. The data show affected riparian vegetation closely mirrors riparian soil concentrations. Only 5 riparian vegetation samples exceeded the NRC MTL of 5.0 mg/kg dw. Vegetation contamination on waste rock dumps is dependent upon the waste rock soil quality. Reclamation quality and slope angle directly influence vegetation quality adjacent to waste rock dumps.

The temporal extent of selenium mobility is moderately well defined seasonally in riparian and upland vegetation. No significant difference was observed during a limited riparian vegetation study. Livestock exposure to seleniferous vegetation should be controlled during summer months. The temporal extent of these studies is sufficient to characterize the nature and extent of selenium in terrestrial receptors.

Data Gaps

Characterize vegetation quality (selenium content) on waste rock dumps because the National Research Council recently raised the maximum tolerance level for selenium from 2 mg/kg (~ 2.4 mg/kg dw) to 5.0 mg/kg dw.

Media: Facilities Investigation

Scope of Work
Site Investigation, Task 1—Surface Water and Sediment Investigation
Task 7—Facilities Investigation

Objectives

- Identify those P4 facilities located at Enoch Valley, Henry, and Ballard mines, which play a role in understanding the physical extent of historical mining activities (and thus, the potential that some or all of those facilities may have to release or cause the transport of, or be affected by, constituents of potential concern).

Investigation Effort

- Mapping events—12
- Facility categories
  - — Mine pits (MMPXXX)
  - — Waste rock dumps (MWDXXX)
  - — Production wells (MPWXXX)
  - — Agricultural wells (MAWXXX)
  - — Domestic wells (MDWXXX)
  - — Stock ponds (MSPXXX)
  - — Springs (MSGXXX)
  - — Dump seeps (MDSXXX)
  - — Streams (MSTXXX)
  - — Reservoir (MRVXXX)

Discussion

The spatial extent of Monsanto facilities is moderately well understood, with the exception of circum-dump reconnaissance to determine present footprints. The various facilities located in and adjacent to Monsanto mines have been mapped by MWH.

The temporal extent of mapping has been conducted over numerous events in an effort to refine facility maps related to the IMA and currently those facilities which are related to Monsanto mining activities. These facilities have undergone various updates, as information on new facilities (typically springs or seeps) is discovered.

Data Gaps

Update maps with recent aerial photographs, maps, and any additional relevant historical information regarding operations, and incorporate the results of the geo-reconnaissance of waste dumps mentioned above under Task 4. Potential need to survey major features.

Appendix L
Analysis and Discussion of Preliminary Risk-based Benchmarks

Analysis and Discussion of Preliminary Risk-based Benchmarks

Introduction

This appendix presents the list of potential preliminary risk-based benchmarks (PRBBs) that are available for selection and use in the P4 Comprehensive Selenium Investigation, conducted under the AOC/CO between P4 and IDEQ. It also presents a list of risk-based benchmarks for human and ecological health. Using these benchmarks, one may conduct a preliminary screen of the environmental media collected to date, for the various target analytes for which benchmarks exist.

The rationale in selecting certain PRBBs for use in the ARM or wire diagrams is explained in the appropriate report sections of the SI-ES. Thus, only supporting discussion for the use and applicability of each PRBB presented in Table 1, *Ecological and Human Health PRBB Comparison Table*, where appropriate, is presented in this appendix.

Rationale

The PRBBs presented in Table 1 are those which are deemed most suitable for selection. Within this table, various screening benchmarks for ecological and human health are presented. This selection step should be completed prior to the selection of site-specific screening benchmarks for use in the risk assessment process. Thus, these PRBBs presented are to be used as screening level information only.

The application and appropriateness for the selection of benchmarks should be considered and agreed by both P4 and IDEQ to determine which benchmark most closely represents the characteristics of the study area. After selection of a PRBB for a particular medium and analyte, the decision should be documented by both P4 and IDEQ to reduce the need to revisit PRBB evaluation and selection, allowing the screening process to move forward.

Additionally, these PRBBs have not been adjusted to account for non-carcinogen cumulative effects in Table 1. Rather, they are presented as is, but rounded to two significant figures to maintain consistency with other PRBBs and the various media concentrations against which, the PRBBs will be compared. Once the selection process of determining PRBBs for various media and analytes has been completed, mathematical adjustment can occur (using 10% of the listed non-carcinogen PRBBs to account for cumulative effects).

Presented in Table 1 are those values which have been specifically requested by IDEQ and other agencies, presented in their comments on the draft PIES report. Few sources were not locatable within the timeframe of addressing their comments by December 1, 2007. Thus, few of the sources for PRBBs are not presented in the table. P4 welcomes these sources when they are made available by USEPA.

The values in Table 1 represent various Idaho State and United States federal PRBBs for evaluation and selection. Additionally, there are other sources for PRBBs which are presented from published scientific papers. P4 recommends that the use of PRBBs which are not state or federal benchmarks from regulatory authorities be restricted to those technical papers which are peer-reviewed and published in reputable scientific journals, and be reviewed for their appropriateness, relevance, and applicability (e.g., those studies specifically related to selenium exposure and cold water fishes).

The second table presented herein, Table 2, *Alternative Screening Benchmarks* presents a list of alternative benchmarks against, which have not been evaluated to determine their suitability. Table 2 represents information that was downloaded from http://rais.ornl.gov/cgi-bin/eco/ECO_select and represents a large number of potential screening benchmarks for surface water, sediment, soil, and aquatic and terrestrial ecological receptors.

Table 1. Ecological and Human Health PRBB Comparison Table																																						
	Surface Water								Sediment						Salmonid Fish (fillet)					Forage Fish (whole-body)					Benthic Macroinvertebrate	Riparian Soil								Riparian Vegetation				
	May 2004								May 2004						May 2004					May 2004					June 2004	September 2004								September 2004				
	(mg/L)								Total (mg/kg dw)						Total (mg/kg dw)					Total (mg/kg dw)					Total (mg/kg dw)	Total (mg/kg dw)								Total (mg/kg dw)				
PRBBs	**Se**	**Cd[a]**	**Unspeciated Cr**	**Cr[III][a]**	**Cr[VI]**	**Ni[a]**	**V**	**Zn[a]**	**Se**	**Cd**	**Cr**	**Ni**	**V**	**Zn**	**Se**	**Cd**	**Ni**	**V**	**Zn**	**Se**	**Cd**	**Ni**	**V**	**Zn**	**Se**	**Se**	**Cd**	**Cr**	**Cu**	**Mo**	**Ni**	**V**	**Zn**	**Se**	**Cd**	**Cu**	**Mo**	**Zn**
Potential Range min	**0.00039**	**0.00015**	**0.0058**	**0.042**	**0.011**	**0.0040**	**0.0081**	**0.059**	**1.9**	**0.60**	**37**	**16**	**35**	**120**	**8.8**	**na**	**na**	**na**	**na**	**6.8**	**1.4**	**27**	**1.4**	**410**	**3.0**	**0.21**	**0.0022**	**0.40**	**5.4**	**2.0**	**14**	**1.6**	**6.6**	**5.0**	**4.2**	**40**	**5.0**	**500**
max	**0.18**	**0.25**	**8.7**	**55**	**0.11**	**0.73**	**0.97**	**43**	**7.5**	**9.2**	**190**	**49**	**72**	**460**	**8.8**	**na**	**na**	**na**	**na**	**7.9**	**1.4**	**27**	**1.4**	**410**	**3.0**	**5,700**	**1,000**	**2,300**	**42,000**	**5,700**	**23,000**	**1,150**	**310,000**	**5.0**	**10**	**88**	**5.0**	**620**
Ecological Sources																																						
IDAPA 58.01.02[b]	0.0050	0.00060	--	0.074	0.011	0.052	--	0.12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NOAA SQRT[c] (Threshold effects level)	0.0050	0.00025	--	0.074	0.011	0.052	--	0.12	--	0.60	37	18	--	120	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NOAA SQRT[c] (Probable effects level)	--	--	--	--	--	--	--	--	--	3.5	90	36		320	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
USEPA 2006[d]	0.0050	0.00025	--	0.074	0.011	0.052	--	0.12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NRC MTLs (2005)[e,f]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	120	230	2,300	920	120	2,300	1,150	11,500	5.0	10	40	5.0	500
USEPA Region 4[g]	0.0050	0.00066	--	0.12	0.011	0.088		0.059	--	1.0	52	16	--	120	--	--	--	--	--	--	--	--	--	--	--	0.81	1.6	0.40	40	2.0	30	2.0	50	--	--	--	--	--
USEPA Region 5[h]	--	0.00015	--	0.042	--	0.029	0.012	0.066	--	0.99	43	23	--	120	--	--	--	--	--	--	--	--	--	--	--	--	0.0022	0.40	5.4	--	14	1.6	6.6	--	--	--	--	--
USEPA Redbook[i]	--	0.0012	0.10	--	--	0.39	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NOAA[j]	--		--	--	--	--	--	--	--	1.2	81	21	--	150	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ORNL[k]	0.00039	0.0011	--	0.21	0.011	0.16	0.020	--	--	4.2	160	39	--	270	--	--	--	--	--	--	--	--	--	--	--	0.21	4.0	0.40	60	2.0	30	2.0	8.5	--	--	--	--	--
Lemly[l]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.0	--	--	--	--	--	--	--	--	--	--	--	--	--
RMP Monitoring Action Level[m]	0.0016	0.00070	0.0058	--	--	0.0040	0.0081	0.059	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
RMP Removal Action Level[m]	0.0050	0.0010	0.074	--	--	0.16	0.020	0.10	2.6	5.1	100	44	72	320	--	--	--	--	--	--	--	--	--	--	--	5.2	14	130	120	--	47	100	740	5.0	4.2	88	--	620
RMP Removal Action Level (non-CWA/IDAPA waters or sediments not supporting aquatic life)[m]	see note	0.25	8.7	--	--	0.61	0.97	43	7.5	9.2	190	44	72	210	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
USEPA Draft Aquatic Life Criterion[n]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8.8	--	--	--	--	7.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MacDonald et. al., 2000[o]	--	--	--	--	--	--	--	--	--	0.99	43	23	--	120	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MacDonald et. al., 2000[p]	--	--	--	--	--	--	--	--	--	5.0	110	49	--	460	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Human Health Sources																																						
USEPA Region 9 PRGs--Tap Water and Residential Soil[q]	0.18	0.018	--	55	0.11	0.73	0.036	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	390	37	210	3,100	390	1,600	78	23,000	--	--	--	--	--
USEPA Region 9 PRGs--Industrial Soil[q]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5,100	450	450	41,000	5,100	20,000	1,000	100,000	--	--	--	--	--
USEPA Region 6 PRGs--Tap Water and Residential Soil[r]	0.18	0.018	--	55	0.11	0.73	0.037	11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	390	39	210	2,900	390	1,600	78	23,000	--	--	--	--	--
USEPA Region 6 PRGs--Industrial Outdoor Worker Soil[r]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5,700	560	500	42,000	5,700	23,000	1,100	100,000	--	--	--	--	--
USEPA National Primary Drinking Water Standards[s]	0.050	0.0050	0.10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
USEPA Region 3 PRGs[t]	0.18	0.018	--	55	0.11	0.73	0.037	11	--	--	--	--	--	--	--	--	--	--	--	6.8	1.4	27	1.4	410	--	5,100	1,000	--	41,000	5,100	20,000	1,000	310,000	--	--	--	--	--
USEPA Region 3 PRGs[u]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	390	78	--	3,100	390	1,600	78	23,000	--	--	--	--	--
Thompson et. al., 2005[v]	--	--	--	--	--	--	--	--	1.9	--	48	23	35	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

[a]Indicates hardness-dependant benchmark. Value presented is based upon a hardness of 100 mg/L $CaCO_3$. Actual benchmarks to be calculated for respective station hardness concentrations.

[b]Represents the CCC freshwater concentration from IDAPA 58.01.02-Water Quality Standards, 2006.

[c]NOAA SQRT tables, February 2004. Sediment benchmarks are from the freshwater sediment threshold and probable effects levels.

[d]National Recommended Water Quality Criteria. Office of Water, USEPA, 2006

[e]Preliminary risk-based benchmarks for riparian soil are derived from MTL's published in NRC (2005). Each MTL was multiplied by 23, which represents a 95th percentile estimate of the fraction of a dry-weight diet for pastured dairy cattle that is incidentally ingested soil. Soil ingestion rate information from Fries et al. (1982).

[f]Preliminary risk-based benchmarks for riparian vegetation are MTL's published in NRC (2005).

[g]EPA Region 4 Ecological Risk Assessment Bulletins--Supplement to RAGS from www.epa.gov/region4/waste/ots/ecolbul.htm. 2001. Chronic screening values only in dry weight.

[h]EPA Region 5 RCRA Corrective Action Ecological Screening Levels. Hardness-based criteria calculated using 50 mg/L $CaCO_3$, due to commonly soft water in Region 5. Unsure of dry weight reporting for solid matrices.

[i]USEPA Quality Criteria for Water (Redbook). 1976

[j]NOAA Sediment Quality Guidelines developed for National Status and Trends Program. ERL in dry weight

[k]ORNL Preliminary Remediation Goals for Ecological Endpoints ES/ER/TM-162/R2. 1997. Hardness-dependent criteria calculated at 100 mg/L $CaCO_3$. Assumed to be in dry weight.

[l]Lemly, D.A., 2002, "Selenium Assessment in Aquatic Ecosystems, A guide for Hazard Evaluation and Water Quality Criteria", Springer-Verlag, New York

[m]Idaho DEQ Area Wide Risk Management Plan, February 2004. Those surface waters not subject to CWA/IDAPA biota standards have a variable set of criteria for selenium in surface waters. The values are 0.0050, 0.050, and 0.201 mg/L for riparian habitat use (protective of waterfowl/amphibians), veterinarian advisory level for domestic animals, and 1/2 NOAEL single median estimate for sensitive species, respectively.

[n]USEPA Draft Aquatic Life Water Quality Criteria for Selenium-2004. EPA-822-D-04-001.

[o]MacDonald et. al. 2000. Consensus based threshold effects concentrations.

[p]MacDonald et. al. 2000. Consensus based probable effects concentrations.

[q]USEPA Region 9 PRGs for residential and industrial soil, evaluated under the direct contact exposure pathway. October 2004. Tap water PRGs should only be applied to those surface waters in the program area that are used for drinking water supplies.

[r]USEPA Region 6 PRGs. Tap water PRGs should only be applied to those surface waters in the program area that are used for drinking water supplies.

[s]USEPA MCLs http://www.epa.gov/safewater/contaminants/index.html#listmcl These standards should only be applied to those surface waters in the program area that are used for drinking water supplies.

[t]USEPA Region 3 PRGs. Tap water risk-based concentrations are placed in the surface water column, and should only be applied to those surface waters in the program area that are used for drinking water supplies. Fish tissue concentrations are presented in neither wet nor dry weight concentrations. Industrial soil risk-based concentrations for riparian soil.

[u]USEPA Region 3 PRGs. Residential soil risk-based concentrations for riparian soil.

[v]Thompson et. al., Derivation and use of sediment quality guidelines for ecological risk assessment of metals and radionuclides released to the environment from uranium mining and milling activities in Canada. Lowest effect level (LEL), derived from the weighted method as recommended by author(s).

Any exceedance of PRBBs does not necessarily consitute an unacceptable risk.

No other requested risk-based benchmarks are presented in this table, as these various requested source were not available at the time of publishing.

NA - Not analyzed.

NE - Not electrofished, station was not electro-fished (i.e., not applicable for electro-fishing).

NS - Not sampled. For Fish investigations, the station was electro-fished, but no sample was obtained.

Table 1 presents those PRBBs which are from recommended or requested sources, as per agency comments on the draft SI-ES. The request for human health PRBBs is honored by presenting drinking water MCLs and soil preliminary remediation goals (PRGs) for residential and industrial exposure. The comparison of drinking water maximum contaminant levels (MCLs) to surface water concentrations is appropriate only where known or possible drinking water allotments exist in the area potentially influenced by P4 mining activity. These MCLs may also be used in the selection of groundwater PRBBs. However, the evaluation of groundwater is contained in other technical memoranda to be produced by P4 and is not covered in the SI-ES. The application of soil PRGs to sediment concentrations should be evaluated prior to their application for applicability, appropriateness, and relevance.

Those PRBBs which are hardness-specific benchmarks for cadmium, chromium, nickel and zinc are moving values. These values are dependent upon the measured hardness of the water at the time the sample was collected and analysed for any of the hardness-dependent benchmarks. For ease of presentation, all hardness dependent benchmarks are presented at the assumed concentration of 100 mg/L calcium carbonate ($CaCO_3$). The actual screening conducted by P4 is completed using the hardness concentration at that particular sampling location, which directly correlates to the hardness-specific analyte of interest. One comment made by the agencies regarding the use of the lowest hardness value at any one time at a particular sampling station presents an uncorrelated comparison between to unrelated values. In short, using the lowest hardness concentration at a station to compare it to all hardness dependent target analyte concentrations at that station does not account for $CaCO_3$ fluctuations. Nor does it account for any correlation, if any, in fluctuating hardness and target analyte concentrations. Comparing the lowest measured hardness to any concentration measured at a particular source incorrectly assumes that hardness does not fluctuate temporally. Thus, P4 will continue to use the correlated hardness and hardness-specific benchmark during screening activities. However, for the purpose of clarity, hardness concentrations can be presented in concert with target analyte concentrations, providing transparency for the reviewer.

USEPA Region 3 PRGs for fish tissue are neither based on wet or dry weight concentrations (J. Hubbard, pers. comm.) and are not necessarily suitable for use as PRBBs for screening fish tissue concentrations (More information regarding Region 3 guidance can be found at http://www.epa.gov/reg3hwmd/risk/human/info/faq.pdf, FAQ #15) due to fish whole body and tissue dry weight concentrations. The increase in tissue concentrations when moving from a wet weight basis to a dry weight basis is well understood. It is not uncommon for tissue concentrations to increase by as much as a factor of 4 when calculating a dry weight equivalency. Thus, the use of the Region 3 PRBBs requires greater evaluation and agreement by P4 and IDEQ to determine the applicability of neither dry nor wet weight PRBBs.

The second table presented herein, Table 2, *Alternative Screening Benchmarks,* presents a list of alternative benchmarks, which have not been evaluated to determine their suitability. Table 2 represents information that was downloaded from http://rais.ornl.gov/cgi-bin/eco/ECO_select and represents a large number of potential screening benchmarks for aquatic and terrestrial ecological receptors.

Table 2. Alternative Screening Benchmarks

Analyte	ARCS NEC Sediment Screening Benchmark mg/kg 24	ARCS PEC Sediment Screening Benchmark mg/kg 25	ARCS TEC Sediment Screening Benchmark mg/kg 26	BCMOELP 1998 Fish Screening Benchmark mg/kg 1	CCME 1999 Piscivorous Wildlife Screening Benchmark mg/kg 2	CEC 1988 Fish Screening Benchmark mg/kg 3	Canadian ISQG Sediment Screening Benchmark mg/kg 27	Canadian PEL Sediment Screening Benchmark mg/kg 28	Canadian WQG Surface Water Screening Benchmark mg/L 63	Consensus PEC Sediment Screening Benchmark mg/kg 29	Consensus TEC Sediment Screening Benchmark mg/kg 30	Dutch Intervention Soil Screening Benchmark mg/kg 50	Dutch Target Soil Screening Benchmark mg/kg 51	EC20 Daphnids Surface Water Screening Benchmark mg/L 64	EC20 Fish Surface Water Screening Benchmark mg/L 65	EC20 Sensitive Species Surface Water Screening Benchmark mg/L 66	EC25 Bass Population Surface Water Screening Benchmark mg/L 67
Cadmium	41.1	11.7	0.592	-	-	-	0.6	3.5	0.000017	4.98	0.99	12	0.8	0.00075	0.0018	0.000013	0.0043
Chromium III	312	159	56	-	-	-	37.3	90	0.0089	111	43.4	230	100	-	0.089	0.00844	0.126
Chromium VI	-	-	-	-	-	-	-	-	0.001	-	-	-	-	0.0005	0.051	0.000266	0.316
Copper	54.8	77.7	28	-	-	-	35.7	197	0.002	149	31.6	190	36	0.000205	0.005	0.00026	0.0086
Molybdenum	-	-	-	-	-	-	-	-	0.073	-	-	480	3	0.36	-	-	-
Nickel	37.9	38.5	39.6	-	-	-	-	-	0.065	48.6	22.7	210	35	0.045	0.062	0.011	0.215
Selenium	-	-	-	-	-	-	-	-	0.001	-	-	5	0.7	0.025	0.04	0.0026	-
Vanadium	-	-	-	-	-	-	-	-	-	-	-	250	42	0.43	0.041	-	0.032
Zinc	541	1530	159	-	-	-	123	315	0.03	459	121	720	140	-	0.047	0.021	0.08

Analyte	ECW Avian Blood Screening Benchmark mg/kg 4	ECW Avian Bone Screening Benchmark mg/kg 5	ECW Avian Brain Screening Benchmark mg/kg 6	ECW Avian Carcass Screening Benchmark mg/kg 7	ECW Avian Diet Screening Benchmark mg/kg 8	ECW Avian Egg Screening Benchmark mg/kg 9	ECW Avian Kidney Screening Benchmark mg/kg 10	ECW Avian Liver Screening Benchmark mg/kg 11	ECW Fish Brain Screening Benchmark mg/kg 12	ECW Fish Egg Screening Benchmark mg/kg 13	ECW Fish Muscle Screening Benchmark mg/kg 14	ECW Fish Whole Body Screening Benchmark mg/kg 15	ECW Mammal Blood Screening Benchmark mg/kg 16	ECW Mammal Fat Screening Benchmark mg/kg 17	ECW Mammal Kidney Screening Benchmark mg/kg 18	ECW Mammal Liver Screening Benchmark mg/kg 19	EPA R4 Acute Surface Water Screening Benchmark mg/L 68
Cadmium	-	-	-	-	2	-	100	40	-	-	-	-	-	-	100	-	0.00179
Chromium III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.98432
Chromium VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016
Copper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00922
Molybdenum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.789
Selenium	-	-	-	-	-	3	-	3	-	-	-	-	-	-	-	-	0.02
Vanadium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06504

Analyte	EPA R4 Chronic Surface Water Screening Benchmark mg/L 69	EPA R6 Earthworms Surface Soil Screening Benchmark mg/kg 56	EPA R6 Plants Surface Soil Screening Benchmark mg/kg 57	Eco-SSL Avian Soil Screening Benchmark mg/kg 52	Eco-SSL Inverts Soil Screening Benchmark mg/kg 53	Eco-SSL Mammalian Soil Screening Benchmark mg/kg 54	Eco-SSL Plants Soil Screening Benchmark mg/kg 55	Environment Ontario 1984 Piscivorous Wildlife Screening Benchmark mg/kg 20	FDEP PEL Sediment Screening Benchmark mg/kg 31	FDEP TEL Sediment Screening Benchmark mg/kg 32	LCV Aquatic Plants Surface Water Screening Benchmark mg/L 70	LCV Daphnids Surface Water Screening Benchmark mg/L 71	LCV Fish Surface Water Screening Benchmark mg/L 72	LCV Non-Daphnid Inverts Surface Water Screening Benchmark mg/L 73	NAWQC Acute Surface Water Screening Benchmark mg/L 74	NAWQC Chronic Surface Water Screening Benchmark mg/L 75	NOAA ERL Sediment Screening Benchmark mg/kg 33
Cadmium	0.00066	110	29	0.77	140	0.36	32	-	4.21	0.676	0.002	0.00015	0.0017	-	0.002	0.00025	1.2
Chromium III	0.11732	0.4	5	26	-	34	-	-	160	52.3	0.397	0.044	0.0686	-	0.57	0.074	81
Chromium VI	0.011	-	-	-	-	81	-	-	-	-	0.002	0.00613	0.0732	-	0.016	0.011	-
Copper	0.00654	61	100	28	80	51	70	-	108	18.7	0.001	0.00023	0.0038	0.00607	0.013	0.009	34
Molybdenum	-	-	2	-	-	-	-	-	-	-	-	0.88	-	-	-	-	-
Nickel	0.08771	200	30	-	-	-	-	-	42.8	15.9	0.005	0.005	0.035	0.128	0.47	0.052	20.9
Selenium	0.005	70	1	-	-	-	-	-	-	-	0.1	0.0917	0.0883	-	-	0.005	-
Vanadium	-	-	2	7.8	-	280	-	-	-	-	-	1.9	0.08	-	-	-	-
Zinc	0.05891	120	190	-	-	-	-	-	271	124	0.03	0.0467	0.0364	5.24	0.12	0.12	150

Analyte	NOAA ERM Sediment Screening Benchmark mg/kg 34	New York State DEC Cancer Piscivorous Wildlife Screening Benchmark mg/kg 21	New York State DEC Noncancer Piscivorous Wildlife Screening Benchmark mg/kg 22	ORNL Invertebrates Soil Screening Benchmark mg/kg 58	ORNL Lowest Chronic Value Daphnids Equilibrium Partitioning EqP Benchmark mg/kg 37	ORNL Lowest Chronic Value Fish EqP Sediment Screening Benchmark mg/kg 38	ORNL Lowest Chronic Value Nondaphnid InvertsEqP Sediment Screening Benchmark mg/kg 39	ORNL Microbes Soil Screening Benchmark mg/kg 59	ORNL Plants Screening Benchmark mg/kg 60	ORNL Secondary Chronic Value EqP Sediment Screening Benchmark mg/kg 40	OSWER Ambient Water Quality Criteria mg/L 76	OSWER Ecotox Thresholds Sediment Screening Benchmark mg/kg 41	OSWER Tier II Secondary Surface Water Screening Benchmark mg/L 77	Ontario Low Sediment Screening Benchmark mg/kg 35	Ontario Severe Sediment Screening Benchmark mg/kg 36	SD EPA R4 Sediment Screening Benchmark mg/kg 43	SD EPA R5 ESL Sediment Screening Benchmark mg/kg 45
Cadmium	9.6	-	-	20	-	-	-	20	4	-	0.001	1.2	-	0.6	10	1	0.99
Chromium III	370	-	-	0.4	-	-	-	10	1	-	0.18	81	-	26	110	52.3	43.4
Chromium VI	-	-	-	0.4	-	-	-	-	1	-	0.01	-	-	-	-	-	-
Copper	270	-	-	50	-	-	-	100	100	-	0.011	34	-	16	110	18.7	31.6
Molybdenum	-	-	-	-	-	-	-	200	2	-	-	-	0.24	-	-	-	-
Nickel	51.6	-	-	200	-	-	-	90	30	-	0.16	21	-	16	75	15.9	22.7
Selenium	-	-	-	70	-	-	-	100	1	-	0.005	-	-	-	-	-	-
Vanadium	-	-	-	-	-	-	-	20	2	-	-	-	0.019	-	-	-	-
Zinc	410	-	-	100	-	-	-	100	50	-	0.1	150	-	120	820	124	121

Analyte	SD EPA R6 FW Sediment Screening Benchmark mg/kg 46	SD EPA R6 Mar Sediment Screening Benchmark mg/kg 47	SO EPA R4 Soil Screening Benchmark mg/kg 61	SO EPA R5 ESL Soil Screening Benchmark mg/kg 62	SW EPA R5 ESL Surface Water Screening Benchmark mg/L 78	SW EPA R6 FW Surface Water Screening Benchmark mg/L 79	SW EPA R6 Mar Surface Water Screening Benchmark mg/L 80	Swain and Holms 1985 Fish Screening Benchmark mg/kg 23	Tier II SAV Surface Water Screening Benchmark mg/L 81	Tier II SCV Surface Water Screening Benchmark mg/L 82	Washington MAEL Sediment Screening Benchmark mg/kg 48	Washington NEL Sediment Screening Benchmark mg/kg 49	OSWER ET Benchmark Identifier mg/kg 42	EPA R4 benchmark Identifier mg/kg 44
Cadmium	0.596	1.2	1.6	0.00222	0.00015	0.0006	0.01	-	-	-	6.7	5.1	ER-L	PQL
Chromium III	37.3	81	0.4	0.4	0.042	0.1008	0.103	-	-	-	270	260	ER-L	TEL
Chromium VI	-	-	-	-	-	0.0106	0.0496	-	-	-	-	-		
Copper	35.7	34	40	5.4	0.00158	0.007	0.0036	-	-	-	390	390	ER-L	TEL
Molybdenum	-	-	2	-	-	2	-	-	16	0.37	-	-		
Nickel	18	20.9	30	13.6	0.0289	0.0874	0.0131	-	-	-	-	-	ER-L	ER-L
Selenium	-	-	0.81	0.0276	0.005	0.005	0.136	-	-	-	-	-		
Vanadium	-	-	2	1.59	0.012	0.02	-	-	0.28	0.02	-	-		
Zinc	123	150	50	6.62	0.0657	0.0581	0.0842	-	-	-	960	410	ER-L	TEL

Notes:

Taken from http://rais.ornl.gov/cgi-bin/eco/ECO_select, updated 7NOV07, accessed 14NOV07.

Benchmark sources for these references can be located at http://rais.ornl.gov/homepage/eco_foot.shtml.

Appendix M
Statistical Processes

M E M O R A N D U M

MWH
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To: P4 Production Project File 1010076
From: W. Wright, MWH
Subject: Statistical Processes

Date: 11-19-07
Reference: 1010076.011602

This memorandum documents the various factors which affect background statistical calculations used on the data given in the *Interim Phase I SIs Evaluation Summary* (SI-ES) report.

The specific factors are:

- sample size (denoted as n),
- variability (as quantified by the sample standard deviation, s),
- representativeness,
- methods,
- the assumption of lognormality,
- reporting limit (denoted as RL),
- the use of a t-test, and
- power (i.e., one minus the type 2 error rate, denoted as $1-\beta$).

Each of these factors is discussed within the context of how background statistics are being used in the preliminary investigation evaluation summary. The discussions, where appropriate, will focus on the functional upper bound of background (FUBOB), which has been defined as the 99.9^{th} percentile of the background distribution defined with 5 percent confidence (denoted as $p_{0.999,0.050,\nu}$, where ν is the degrees of freedom of the background data set).

Sample Size, n

The degrees of freedom of a data set, ν, is a function of n. The higher the ν, the less uncertainty in the data set and therefore the more reliable the statistic (a high-end quantile, for example, which is often the statistic of interest in environmental background characterization). If uncertainty in the statistic is of primary concern—e.g., in circumstances where a confidence bound is being used—the higher the ν the less distance between the confidence bound and the statistic in question.

In the case of the FUBOB, the underlying statistic is the 99.9th percentile of the background distribution (denoted $p_{0.999}$), and is better estimated with a data set having a high ν rather than one having a small ν. However, FUBOB is defined as the lower 95 percent confidence bound on the 99.9th percentile—i.e., the 99.9th percentile defined with a 5 percent confidence. Thus, for a data set having a small ν, the lower confidence bound will reflect the increased uncertainty by being lower—i.e., more distant from the sample estimate of $p_{0.999}$.

The FUBOB was developed in cooperation with IDEQ to specifically ensure that it possessed this property of essentially imposing a penalty for having a small n.

Sample size can also affect quantification of data set variability. This is discussed below under Variability.

Finally, while the relationship between n and ν is typically as follows for a univariate statistical test:

$$\nu = n-1,$$

This relationship does not always hold. When different sampling events exist, the data must first be tested to determine whether differences exist between these events. If not, they can be combined, but the degrees of freedom of the combined data set is lower than if all the samples would have been from a single event. Degrees of freedom are lost by having tested the events. This is one reason why the data set ν may be less than n-1.

Another reason ν may be far less than n-1 is that testing different sampling events shows a difference between events. In such a case the data cannot be combined into a single set; rather, the effective sample size is merely a function of the number of events.

Variability, s

The sample standard deviation, s, is an asymptotically unbiased measure of data variability. A small bias exists for small sample size that is often ignored but is easily accounted for when necessary. When calculating tolerance bounds (such as the FUBOB) or confidence bounds, the statistical constants used incorporate the appropriate bias correction factor. When estimating the true population standard deviation, σ, a bias correction factor (denoted $k_{s,\nu}$) must be applied as follows:

$$\hat{\sigma} = k_{s,\nu} s.$$

The vast majority of statistics texts do not address this topic, as most introductory statistics is not concerned about estimating σ. The topic is well covered in K. Diem (1962, *Documenta Geigy: Scientific Tables*, 6th ed., Geigy Pharmaceuticals), and Diem provides a table of k_s for ν from 1 to 100. Monsanto's consultant has developed an Excel spreadsheet that provides good estimates of $k_{s,\nu}$ for the same range so that the table need not be kept at hand. For a single degree of freedom, $k_{s,1}$ is 1.2533; i.e., s underestimates σ, on average, by about 20 percent:

$$\frac{1}{1.2533}-1=-0.2021.$$

For 100 degrees of freedom, $k_{s,100}$ is 1.0026, a correction small enough to ignore for virtually all environmental endeavors.

In summary, data variability is appropriately quantified by s. It is used, in turn, to quantify uncertainty in a statistic of interest as it is an input variable into equations used to calculate tolerance and confidence bounds. For a given sample size, less variable data sets will have tighter bounds, whereas more variable data sets will have larger bounds.

Representativeness

Representativeness is not a statistical consideration, per se. Rather, it is a quality planning consideration emphasized in the United States Environmental Protection Agency (USEPA) data quality objectives framework. Data are to be collected such that they represent that which they are intended to represent. Perhaps the best example within the context of the selenium program is the issue of unfiltered water samples. Monsanto included unfiltered surface water metals data (excluding selenium) from 1998 in their draft background calculations. After 1998 the Idaho Mining Association began filtering their non-selenium metals samples because their water quality standards are based on their dissolved forms. Thus, unfiltered non-selenium metals data are unrepresentative of filtered non-selenium metals conditions. As such, the IDEQ directed Monsanto to delete the 1998 non-selenium metals data from the background calculations.

Similarly, groundwater standards are based on drinking water standards, which in turn are legally applicable in the water distribution system so as to be representative of what one drinking from a community groundwater source would actually be exposed to. No one drinks water from groundwater monitoring wells, and such wells are often installed in locations that a drinking water well would never be installed in—for example, in areas of low water generating potential. If a monitoring well is installed in such a location and that location happens to have fine sediments, it may be impossible or prohibitive to develop the well such that turbidity-free—i.e., potable—water can be obtained. In such a situation it is necessary to filter the groundwater to yield a representative sample of what a consumer would drink if the monitoring well was, in fact, a drinking water well. No one drinks turbid groundwater, and no soil sample will ever meet drinking water standards.

In the absence of representativeness, statistical calculations are meaningless because the underlying data are meaningless.

Methods

The IDEQ has raised several questions relating to the choice of statistical methods. According to his ten principles of environmental sampling design, R. Green (1979, *Sampling Design and Statistical Methods for Environmental Biologists*, John Wiley & Sons) advocates selecting the statistical method for a given purpose before the data are collected then sticking with the result. As he points out in his Principle 10,

> "An unexpected or undesired result is *not* a valid reason for rejecting the method and hunting for a 'better' one."

Ignoring this precept can be interpreted as statistic shopping and can thus be labeled as unobjective, which compromises the purpose of using statistics.

The FUBOB, which is $p_{0.999,0.050,\nu}$ of the background distribution, was tailored with the help of IDEQ to produce what the name implies: a functional upper bound of the background distribution. An analytical sample result in excess of its respective FUBOB is taken as evidence of mine-specific contamination. The FUBOB has been found to be a more reasonable statistic than the USEPA's tolerance bound of choice, $p_{0.950,0.950,\nu}$. Any effort to replace the FUBOB with an alternative statistic paints the person making that change as unobjective.

Concern has been expressed that the FUBOB is typically larger than the largest corresponding background observation. When dealing with relatively low degrees of freedom, a good upper bound of background should exceed the few observations available. It has been proposed to substitute the maximum background observation for the FUBOB, but the statistical meaning of the use of the maximum is entirely dependent on the degrees of freedom. Unless this is held constant, there is no statistical consistency, and maximum values become meaningful only with relatively large sample sizes. For example, the nonparametric equivalent of the USEPA's tolerance bound of choice—the 95th percentile defined with 95% confidence—is represented by the maximum of 59 random observations (G. Hahn and W. Meeker, 1991, *Statistical Intervals: A Guide for Practioners*, John Wiley & Sons).

Another suggestion has been to use a t-test or some other parametric (or even nonparametric) method of testing differences in means from two groups. The problem is that one has to have at least two groups before one can use such methods. One group for our purposes is easy to define—background. The other group—the affected area—is problematic because not all non-background site characterization samples are necessarily from contaminated environments. As a major point of site characterization is defining contaminant extent, one would expect and hope to find more than several stations within what is effectively background conditions, outside the influence of contamination. By grouping such samples with those from contaminated environs, one dilutes the ability of a t-test or other similar test to see a difference—by lowering the mean and increasing the variance for the "affected" group. The FUBOB approach avoids such problems by allowing each station to be categorized as either contaminated or not.

Lognormality

Concentrations of chemicals in the environment are typically lognormally distributed (G. van Belle, 2002, *Statistical Rules of Thumb*, John Wiley & Sons), as are most environmental parameters. A two-parameter lognormal distribution has a lower bound of zero, which works well with data censored at the reporting limit. A four-parameter lognormal distribution can have a lower bound of zero and an upper bound of 1,000,000 ppm as an arbitrary physical constraint or some lower value if it can be justified. An upper bound prevents inaccurate calculations of upper tolerance bounds, such as a $p_{0.95,0.95}$ that exceeds 1,000,000 ppm.

The four-parameter lognormal distribution makes an excellent null hypothesis of distributional form (see Reporting Limit below). It honors knowledge of environmental chemistry and is easily simplified to a two-parameter lognormal or normal distribution when analyte-and-site-specific data justify such simplification.

Reporting Limit, RL

The value below which a result is considered to be sufficiently unreliable and is thus not reported is the RL. The act of not reporting some results from a data set is called censoring. Censoring is common in engineering failure analysis, as time often precludes testing until failure. In the case of a test going for the maximum time and failure not occurring, the reporting limit the value above which a result was not detected. Failure analysis data sets are censored on the right-hand side. Environmental chemistry data sets are censored on the left-hand side—i.e., censored values are considered to be not detected.

Some modern analytical instruments do not censor themselves when encountering a low concentration. Rather, they generate a reading that can be converted to a concentration via the day's instrument calibration curve. When concentrations are sufficiently low the resulting concentrations can be negative, what one would expect when the signal fails to exceed the instrument noise. In fact, an instrument well calibrated to read a value corresponding to a concentration of zero when a blank is analyzed should, on the basis of random sampling and analytical errors, generate a distribution around zero, with roughly half the concentrations being negative. Such readings are not interpreted as a negative concentration present in the environment—something that is physically impossible; rather, they are merely interpreted as a concentration that is for all practical purposes zero, and they serve as a measure of uncertainty in the data.

The USEPA's contract laboratory program opted to censor data since the data had the potential to be used in court under adversarial conditions. Rather than provide defense council with an argument about the validity of low concentration results, the agency chose to censor results below an RL set at a defined "detection limit" that could be elevated should detections in blanks occur. The arbitrary nature of the "detection limit" is, in part, the basis of a law suit threatened by industry against the agency, which the agency is holding in abeyance with an agency/industry/environmental working group convened to redefine detection and quantitation. The net effect of the work this group is doing appears, if adopted, to move detection and quantitation limits upward (M. Smith, USEPA, personal communication).

With a left-hand censored data set, the resulting validated instrumental results (VIRs) cannot generally be described with the usual two-parameter lognormal distribution—i.e., a distribution where the log-transformed values are normally distributed (with a mean and standard deviation of the log-transformed values) and the lower bound is zero. A three- or four-parameter lognormal distribution must be used on VIRs.

A three-parameter lognormal distribution is one where the log-transformed difference of the values and the lower bound are normally distributed and the lower bound is not necessarily zero. In addition to the lower bound, the other two distribution parameters are the mean of the log-transformed differences, and their corresponding standard deviation. When the lower bound is zero, the three-parameter lognormal distribution becomes a two-parameter lognormal distribution. The mathematical definition of a lognormal distribution is this three-parameter version—something not disclosed in applied statistics textbooks, but consistently defined in books on mathematical probability.

A four-parameter lognormal distribution has an upper bound in addition to the lower bound and the mean and standard deviation of the log-transformed values. The log-transform in this case is applied to the ratio of the difference of the value and the lower bound to the difference of the upper bound and the value. Given that environmental data are typically lognormal, a four-parameter lognormality assumption makes an excellent null hypothesis (see Lognormality above). If the upper bound is found to be very high the distribution can be simplified to a three-parameter lognormal. If the upper bound is found to be very high and the lower bound very low relative to the observed results, then the distribution can be simplified to a normal distribution.

Power, 1-β

Statistical power is one minus the type 2 error (alarm failure) rate; just as statistical confidence is one minus the type 1 error (false alarm) rate. Power is a function of sample size, confidence, and the difference one wishes to discern. Because the IDEQ has not specified a difference they wish to discern, no meaningful estimation of power can be made.

Because power is rarely calculated it is customary to retain (not accept) the null hypothesis in statistical hypothesis testing unless the null hypothesis is rejected. Acceptance of a null hypothesis would imply an acceptable degree of power which, without calculation, is unknown.

Because of IDEQ's reluctance to (1) specify a discernible difference and (2) to be comfortable with a null hypothesis involving a comparison to background that is not rejected, Monsanto agreed to develop the FUBOB (functional upper bound of background) in cooperation with the agency. The FUBOB is the 99.9th percentile of the background distribution bound with a mere 5 percent confidence—i.e., the FUBOB is the 5th percentile of the distribution of possible values of the 99.9th percentile.

Because the FUBOB is a lower confidence bound on a high-end percentile, Monsanto is penalized with low values if a small sample size is used. On the other hand, Monsanto has an incentive to use higher sample sizes, because the FUBOB should then be closer to the actual

99.9th percentile. The USEPA typically uses a 95th percentile defined with 95 percent confidence—i.e., an upper 95 percent confidence bound on the 95th percentile. During the development of the FUBOB, the FUBOB was found to generally be lower than the USEPA's tolerance bound of choice, especially with small samples.

The FUBOB being a lower confidence bound means that power need not be calculated for background comparisons. The IDEQ can be assured that the error rate they are most concerned about is controlled by the confidence level of the lower bound—i.e., that there is but a 5 percent chance that the true 99.9th percentile is lower than the FUBOB.

Appendix N
Principal Component Analysis

M E M O R A N D U M

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From: W. Wright, MWH
Subject: Principal Component Analysis

Date: 11-21-07
Reference: 1010076

This memorandum documents the Principal Component Analysis (PCA) used on the data given in the *Interim Phase I SIs Evaluation Summary* (SI-ES) report. Structure in a multi-dimensional dataset is imparted by correlations between the variables. Most multi-dimensional datasets will appear to have structure when subjected to a PCA. To determine which, if any, of the principal axes contain significant information the following procedure is employed.

A dataset containing the same means and variances as that of the dataset in question for each of the component variables is simulated. The difference is that no correlations are imposed upon the simulated dataset; thus, by definition, the simulated dataset has no real structure. Five simulated data sets are generated, and then a PCA is performed on each dataset. This generates five random eigenvalues for each information-less principal axis that can be used as control axes.

For the larger principal axes the assumption of normality is a good one. It is a bad assumption for the smaller principal axes, but these axes are known to contain only noise, so they really never get tested. Under the assumption of normality a FUBOB is calculated for each principal axis. If the eigenvalue for a given principal axis from the dataset in question exceeds the corresponding FUBOB from the simulated information-less datasets. Once an insignificant principal axis is found, all principal axes with smaller eigenvalues will also be insignificant.

The primary purpose of undertaking a PCA is to hopefully reduce the dimensionality of a multi-dimensional dataset. Ideally, there will be no more than three principal axes with significant information content. Three or fewer dimensions can be easily plotted to allow the structure of the data to be inspected and hopefully better understood. The meaning of an axis can hopefully be elucidated by examining factor loadings for the significant axes. Significant correlations between significant principal axes and environmental variables can also be helpful in interpreting what the axes represent. Insignificant principal axes are considered to contain random noise.

By using PCA in the manner described herein one is essentially performing a reproducible form of factor analysis. This appendix presents the results of the PCAs for the pond and stream riparian habitat assessments. Both are 12-dimensional datasets, and the PCA results show the results for all 12 dimensions. In the main body of the report only the significant dimensions are plotted, interpreted, and discussed.

PRINCIPAL COMPONENTS ANALYSIS FOR POND RIPARIAN HABITAT ASSESSMENT
Analysing 12 variables x 17 cases
Tolerance of eigenanalysis set at 1E-10

Similarity Matrix

	AM	SB	MB	CN	EF	AF	ON	SM	WM	UM	GM	LS
AM	0.059											
SB	0.048	0.191										
MB	0.022	0.088	0.243									
CN	0.055	0.033	0.044	0.110								
EF	-0.022	-0.026	0.070	-0.044	0.243							
AF	0.033	0.132	0.176	0.066	0.011	0.265						
ON	0.055	0.033	0.044	0.048	0.018	0.004	0.110					
SM	0.044	0.051	0.110	0.088	-0.048	0.165	0.026	0.221				
WM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
UM	0.055	0.033	0.044	0.048	0.018	0.066	0.048	0.088	0.000	0.110		
GM	0.059	0.048	0.022	0.055	-0.022	0.033	0.055	0.044	0.000	0.055	0.059	
LS	0.059	0.048	0.022	0.055	-0.022	0.033	0.055	0.044	0.000	0.055	0.059	0.059
	AM	SB	MB	CN	EF	AF	ON	SM	WM	UM	GM	LS

Eigenvalues

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9	Axis 10	Axis 11	Axis 12	
Eigenvalues	0.728	0.327	0.235	0.167	0.093	0.050	0.034	0.023	0.012	0.000	0.000	0.000	1.669
Percentage	43.635	19.620	14.074	9.985	5.549	3.013	2.022	1.368	0.734	0.000	0.000	0.000	0.139
Cumulative percentage	43.635	63.254	77.329	87.314	92.863	95.875	97.897	99.266	100.000	100.000	100.000	100.000	

PCA Variable Loadings

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9	Axis 10	Axis 11	Axis 12
AM	0.178	-0.211	0.272	-0.075	0.045	0.052	0.160	0.000	0.384	0.250	0.777	0.000
SB	0.330	-0.033	-0.081	-0.771	0.222	-0.116	-0.270	0.357	-0.162	0.000	0.000	0.000
MB	0.430	0.433	-0.042	-0.020	-0.649	-0.211	0.346	0.199	0.025	0.000	0.000	0.000
CN	0.247	-0.258	0.132	0.168	-0.204	0.740	-0.039	0.308	-0.376	0.000	0.000	0.000
EF	-0.018	0.728	0.479	0.097	0.305	0.215	-0.225	0.167	0.117	0.000	0.000	0.000
AF	0.523	0.213	-0.356	-0.033	0.268	0.311	0.083	-0.614	0.012	0.000	0.000	0.000
ON	0.155	-0.104	0.510	-0.078	-0.350	-0.193	-0.466	-0.513	-0.244	0.000	0.000	0.000
SM	0.439	-0.136	-0.207	0.540	0.107	-0.278	-0.503	0.260	0.210	0.000	0.000	0.000
WM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
UM	0.245	-0.086	0.305	0.226	0.428	-0.359	0.449	0.045	-0.521	0.000	0.000	0.000
GM	0.178	-0.211	0.272	-0.075	0.045	0.052	0.160	0.000	0.384	-0.798	-0.172	0.000
LS	0.178	-0.211	0.272	-0.075	0.045	0.052	0.160	0.000	0.384	0.548	-0.605	0.000

	Axis 1		
AF	0.523	0.274	0.274
SM	0.439	0.193	0.466
MB	0.430	0.185	0.651
SB	0.330	0.109	0.760
CN	0.247	0.061	0.821
UM	0.245	0.060	0.881
AM	0.178	0.032	0.913
GM	0.178	0.032	0.944
LS	0.178	0.032	0.976
ON	0.155	0.024	1.000
EF	-0.018	0.000	1.000
WM	0.000	0.000	1.000

PCA Case Scores

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9	Axis 10	Axis 11	Axis 12
MSP010	-0.197	-0.163	-0.031	-0.201	-0.142	0.083	-0.039	-0.004	0.044	0.000	0.000	0.000
MSP011	-0.222	0.006	0.185	0.073	-0.014	0.075	0.085	-0.040	-0.016	0.000	0.000	0.000
MSP012	-0.108	-0.210	0.013	0.183	-0.064	-0.048	0.015	-0.017	0.007	0.000	0.000	0.000
MSP014	0.208	0.125	0.013	0.002	-0.027	0.002	-0.002	0.010	0.005	0.000	0.000	0.000
MSP015	-0.140	-0.002	0.165	-0.120	0.041	0.047	0.017	0.049	-0.057	0.000	0.000	0.000
MSP016	-0.026	-0.219	-0.007	-0.009	-0.008	-0.077	-0.053	0.072	-0.033	0.000	0.000	0.000
MSP017	0.208	0.125	0.013	0.002	-0.027	0.002	-0.002	0.010	0.005	0.000	0.000	0.000
MSP018	0.208	0.125	0.013	0.002	-0.027	0.002	-0.002	0.010	0.005	0.000	0.000	0.000
MSP019	0.066	-0.139	-0.223	0.002	0.146	0.049	0.084	0.047	0.031	0.000	0.000	0.000
MSP020	0.208	0.125	0.013	0.002	-0.027	0.002	-0.002	0.010	0.005	0.000	0.000	0.000
MSP021	0.105	-0.165	-0.096	-0.018	0.059	0.001	-0.032	-0.081	-0.030	0.000	0.000	0.000
MSP022	0.101	0.017	0.024	0.007	0.135	0.055	-0.088	-0.040	-0.001	0.000	0.000	0.000
MSP023	0.213	-0.057	-0.106	-0.022	-0.104	-0.052	0.055	-0.032	-0.024	0.000	0.000	0.000
MSP031	0.208	0.125	0.013	0.002	-0.027	0.002	-0.002	0.010	0.005	0.000	0.000	0.000
MSP055	-0.517	0.276	-0.256	0.050	-0.017	-0.010	-0.022	0.000	-0.019	0.000	0.000	0.000
MSP059	-0.202	0.062	0.132	-0.162	0.092	-0.138	0.027	-0.028	0.037	0.000	0.000	0.000
MSP062	-0.113	-0.028	0.133	0.208	0.012	0.006	-0.041	0.025	0.036	0.000	0.000	0.000

Spearman Rank Correlation, ρ, Matrix

	PC1	[Se]sw	[Se]sed
PC1	1		
[Se]sw	-0.1938	1	
[Se]sed	-0.4575	0.46466	1
n	17		
$\lvert r_{0.050} \rvert$	0.4118		

PRINCIPAL COMPONENTS ANALYSIS FOR STREAM RIPARIAN HABITAT ASSESSMENT
Analysing 12 variables x 40 cases
Tolerance of eigenanalysis set at 1E-10

Similarity Matrix

	AM	SB	MB	CN	EF	AF	ON	SM	WM	UM	GM	LS
AM	0.240											
SB	0.109	0.192										
MB	0.035	0.006	0.148									
CN	0.067	0.045	-0.040	0.179								
EF	0.038	0.051	-0.018	0.079	0.092							
AF	-0.038	-0.051	-0.008	-0.028	0.010	0.092						
ON	-0.035	-0.006	0.031	-0.037	-0.033	0.008	0.148					
SM	-0.064	-0.026	0.054	-0.008	-0.021	-0.005	0.023	0.215				
WM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
UM	-0.038	0.026	0.018	0.023	0.010	-0.010	0.033	0.072	0.000	0.092		
GM	-0.006	0.013	0.045	0.058	0.026	-0.026	0.058	0.077	0.000	0.051	0.192	
LS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	AM	SB	MB	CN	EF	AF	ON	SM	WM	UM	GM	LS

Eigenvalues

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9	Axis 10	Axis 11	Axis 12
Eigenvalues	0.438	0.365	0.226	0.153	0.136	0.093	0.074	0.057	0.030	0.020	0.000	0.000
Percentage	27.530	22.923	14.216	9.592	8.567	5.852	4.646	3.555	1.890	1.229	0.000	0.000
Cumulative percentage	27.530	50.453	64.669	74.261	82.829	88.680	93.326	96.881	98.771	100.000	100.000	100.000

PCA Variable Loadings

	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9	Axis 10	Axis 11	Axis 12
AM	0.612	-0.099	-0.402	-0.147	0.321	-0.039	0.430	-0.158	0.300	0.165	0.000	0.000
SB	0.445	-0.247	-0.206	0.092	-0.676	0.170	-0.161	-0.201	-0.167	-0.331	0.000	0.000
MB	-0.089	-0.265	-0.556	-0.201	0.306	0.264	-0.359	0.470	-0.211	-0.124	0.000	0.000
CN	0.359	-0.284	0.544	0.002	0.220	-0.074	0.242	0.420	-0.262	-0.371	0.000	0.000
EF	0.252	-0.127	0.300	0.011	0.034	0.508	-0.196	-0.048	-0.241	0.687	0.000	0.000
AF	-0.144	0.164	0.089	0.043	0.206	0.762	0.212	-0.248	0.171	-0.428	0.000	0.000
ON	-0.229	-0.202	-0.264	0.691	-0.041	0.054	0.486	0.104	-0.290	0.156	0.000	0.000
SM	-0.367	-0.479	0.026	-0.592	-0.143	-0.002	0.375	-0.265	-0.222	0.063	0.000	0.000
WM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
UM	-0.114	-0.325	0.103	0.014	-0.336	0.169	0.080	0.458	0.704	0.130	0.000	0.000
GM	-0.076	-0.599	0.113	0.316	0.346	-0.152	-0.368	-0.428	0.227	-0.097	0.000	0.000
LS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000

PCA Case Scores

	Groups	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7	Axis 8	Axis 9	Axis 10	Axis 11	Axis 12
MDS022	ponded seep	0.055	-0.118	-0.161	-0.026	-0.013	0.056	-0.008	-0.016	0.000	-0.038	0.000	0.000
MSG006	spring	-0.115	-0.062	-0.064	-0.017	0.043	0.035	-0.051	0.042	-0.022	-0.012	0.000	0.000
MST044	stream	-0.043	-0.065	0.112	0.015	0.030	-0.019	0.045	0.034	-0.030	-0.052	0.000	0.000
MST045	ponded stream	0.203	-0.109	0.105	-0.102	-0.015	0.075	-0.021	-0.048	0.000	0.007	0.000	0.000
MST046	stream	0.140	0.098	-0.095	0.050	-0.095	0.039	0.049	0.020	0.033	-0.013	0.000	0.000
MST047	stream	0.140	0.098	-0.095	0.050	-0.095	0.039	0.049	0.020	0.033	-0.013	0.000	0.000
MST049	ponded stream	0.150	-0.147	0.000	0.000	-0.060	-0.120	0.054	0.016	-0.036	-0.010	0.000	0.000
MST050	ponded stream	0.203	-0.109	0.105	-0.102	-0.015	0.075	-0.021	-0.048	0.000	0.007	0.000	0.000
MST054	stream	0.124	0.221	-0.036	-0.077	0.074	-0.024	-0.016	-0.038	-0.007	-0.006	0.000	0.000
MST055	stream	0.087	0.189	-0.078	0.033	0.067	-0.016	0.062	-0.021	-0.053	0.019	0.000	0.000
MST057	ponded stream	0.055	-0.081	0.048	-0.008	0.081	-0.025	0.114	0.008	0.018	-0.025	0.000	0.000
MST058	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST062	stream	0.026	0.237	0.029	-0.054	0.022	-0.018	-0.085	-0.013	-0.055	-0.032	0.000	0.000
MST063	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST064	stream	-0.016	-0.078	-0.128	-0.041	0.095	0.029	0.018	0.016	0.026	0.015	0.000	0.000
MST066	stream	-0.029	0.153	0.003	0.059	-0.038	0.018	0.006	0.077	0.011	0.013	0.000	0.000
MST067	stream	-0.088	0.076	0.007	-0.036	-0.061	0.017	0.066	0.035	-0.024	0.024	0.000	0.000
MST069	stream	-0.088	0.076	0.007	-0.036	-0.061	0.017	0.066	0.035	-0.024	0.024	0.000	0.000
MST089	stream	-0.051	0.109	0.049	-0.146	-0.054	0.009	-0.012	0.018	0.022	-0.001	0.000	0.000
MST090	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST092	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST093	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST094	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST095	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST096	ponded stream	0.078	-0.144	-0.176	-0.033	-0.046	-0.066	-0.042	0.024	-0.028	0.030	0.000	0.000
MST101	ponded stream	0.056	-0.009	0.156	0.112	0.058	0.063	-0.046	0.068	-0.033	0.048	0.000	0.000
MST130	stream	-0.043	-0.065	0.112	0.015	0.030	-0.019	0.045	0.034	-0.030	-0.052	0.000	0.000
MST133	stream	-0.006	-0.086	-0.022	0.023	-0.147	-0.102	-0.053	-0.026	-0.042	0.023	0.000	0.000
MST134	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST135	stream	-0.115	-0.062	-0.064	-0.017	0.043	0.035	-0.051	0.042	-0.022	-0.012	0.000	0.000
MST136	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST143	stream	0.030	0.017	-0.012	0.124	-0.091	0.021	-0.079	-0.023	0.021	-0.055	0.000	0.000
MST144	stream	-0.100	-0.020	0.025	0.015	-0.006	-0.007	0.007	-0.034	0.012	0.008	0.000	0.000
MST236	ponded stream	0.174	0.002	0.071	-0.031	0.078	-0.156	-0.058	0.074	0.073	0.008	0.000	0.000
MST272	stream	-0.115	-0.062	-0.064	-0.017	0.043	0.035	-0.051	0.042	-0.022	-0.012	0.000	0.000
MST273	stream	-0.051	0.109	0.049	-0.146	-0.054	0.009	-0.012	0.018	0.022	-0.001	0.000	0.000
MST274	stream	-0.041	0.057	0.021	0.110	0.017	-0.007	-0.053	0.009	0.048	-0.002	0.000	0.000
MST275	ponded stream	0.226	-0.064	0.059	0.103	0.001	0.084	-0.003	0.011	-0.011	0.022	0.000	0.000
MST276	stream	-0.016	-0.078	-0.128	-0.041	0.095	0.029	0.018	0.016	0.026	0.015	0.000	0.000
MST277	stream	0.075	0.093	-0.060	0.084	0.123	-0.040	0.003	-0.090	-0.017	0.003	0.000	0.000

Spearman Rank Correlation, ρ, Matrix

	PC1	PC2	$[Se]_{sed}$	$[Se]_{sw}$	$[Se]_{rsoil}$	$[Se]_{rveg}$	n = 40
PC1	1.000						$\lvert r_{0.050} \rvert = 0.312$
PC2	-0.038	1.000					
$[Se]_{sed}$	-0.410	-0.102	1.000				
$[Se]_{sw}$	-0.509	-0.101	0.616	1.000			
$[Se]_{rsoil}$	-0.518	-0.023	0.666	0.409	1.000		
$[Se]_{rveg}$	-0.291	-0.171	0.561	0.487	0.473	1.000	

ATTACHMENT A

PRINCIPAL COMPONENTS ANALYSIS

Excerpts from *The Ordination of Ecological Data: A Primer on Classification and Ordination*, by E. C. Pielou, 1984, John Wiley & Sons, New York.

ORDINATION

Ordination is a procedure for adapting a multidimensional swarm of data points in such a way that when it is projected onto a two-space (such as a sheet of paper) any intrinsic pattern the swarm may possess becomes apparent. Several different projections onto differently oriented two-spaces may be necessary to reveal all the intrinsic pattern. Projections onto three-spaces to give solid three-dimensional representations of the data can also be made....

PRINCIPAL COMPONENT ANALYSIS

The new axes...are known as the first, second, and *s*th *principal axes* of the data. The new coordinates of the data points measured along these new axes are known as *principal component scores*. [Note: *s* is the number of variables.]

The term *principal component* denotes the variable "the principal component score for any data point"; hence the *i*th principal component of the data is

$$y_i = u_{i1}x_1 + u_{i2}x_2 + \dots + u_{is}x_s.$$

[Note: x_s refers to the *s*th original data axis, and y_i refers to the *i*th new principal axis.]

The final step in an ordination by PCA, the step that enables the result of a PCA to be interpreted, is to inspect the pattern of the data points when they are projected onto planes defined by the new, rotated axes (the principal axes).

PCA...is often used as an ordination method in ecological work. Such an ordination is a "success" if a large proportion of the total dispersion (or scatter) of the data is parallel with the first two or three principal axes; for then this large proportion of the information contained in the original, unvisualizable *s*-dimensional data swarm can be plotted in two-space or three-space and examined. This is what ordination by PCA sets out to achieve: the data swarm is to be projected onto the two-dimensional or three-dimensional frame (or frames) that most clearly reveals the real pattern of the data. When three axes are retained, as is very often done, the result is shown in print either as a two-dimensional perspective (or isometric) drawing of a three-dimensional graph, or else as a trio of two-dimensional graphs showing the swarm projected onto the y_1, y_2 plane, the y_1, y_3 plane, and the y_2, y_3 plane, respectively.

The statement that such a two- or three-dimensional display of the original *s*-dimensional data swarm reveals the real pattern of the data is intuitively reasonable, but it is desirable to define more precisely what is meant by “real pattern.” The observed abundances of a large number of species co-occurring in an ecological sampling unit are governed by two factors: first, the joint responses of groups of species to persistent features of the environment; second, the “capricious,” unrelated responses of a few individual members of a few species to environmental accidents of the sort that occur sporadically, here and there, and have only local and temporary effects. In the present context the joint, related responses of groups of species constitute “real pattern” or “interesting data structure,” and the capricious, sporadic responses amount to “noise.”

It has been shown…that displaying the results of a PCA, or indeed of any ordination, in only a few dimensions (typically two or three) does more than merely permit an unvisualizable *s*-dimensional pattern to be visualized; it also suppresses “noise.” This is because the first few principal components of the data—those with the largest variances—nearly always reflect the concerted responses of groups of several species. When a group of species (hence numerous individuals) behave in concert, it is unlikely to be the result of localized, temporary “accidents.” Moreover, the fact that many species do, indeed, respond in concert to the “important” features of the environment means that the data body as a whole contains redundancies; therefore, the number of coordinate axes needed to display the “interesting structure” of the data is far less than *s*, the total number of species observed.

To summarize: ordination permits us to profit from the redundancy in field data. Because of redundancy, not much information is lost by representing a swarm of data points in only a few dimensions. And the discarded information (on the disregarded axes along which the variances are small) is mostly noise….

FOUR DIFFERENT VERSIONS OF PCA

[Centered] PCA can be modified in one or both of two ways.

First, one can standardize (or rescale) the data by dividing each element in the centered data matrix…by the standard deviation of the elements in its row. The PCA is now carried out…[on] the correlation matrix instead of the covariance matrix.

The second modification consists of using uncentered data.

Of course, both these modifications can be made simultaneously.

[T]he effect of standardizing the raw data…is to make the variances of…[all] sets of coordinates equal to unity. Standardizing the data, therefore, alters the shape of the swarm; after standardization, the swarm is noticeably less elongated than it was before.

In some analyses standardization of the data is a (possibly) desirable option; in others it is a necessity.

Standardization is often desirable as a way of preventing the “swamping” of the uncommon species in a community by the common or abundant ones. Unless data are standardized, the dominant species are likely to dominate the analysis. This happens because the quantities of abundant species tend to have higher variances (as well as higher means) than the quantities of uncommon species. Standardization equalizes all the variances before axis rotation (the analysis itself) is carried out. Thus, if one wishes subordinate species to have an appreciable effect on the outcome, it is a good idea to use standardized data.

However, this does not mean that standardization is always desirable. It is a matter of judgment. It could well be argued that the dominant species ought to control the result simply because they are dominant. Further, there is a risk that standardization may give rare species an undesirable prominence; if their presence is due only to chance, and is not a response to an environmental variable of interest, they are merely “noise.” Therefore, deciding whether to standardize or not to standardize entails a trade-off between underemphasizing and overemphasizing the less common species. A useful compromise is to exclude truly rare species from the raw data, and after that to standardize these edited data for analysis….

Standardization of the data must be done when the quantities of the different species are measured in different units. When this is done, the species quantities are obviously noncomparable in their raw form and should be standardized before an analysis is done.

Data matrices whose elements are the values of noncomparable environmental variables should also be standardized.

Ordinations, especially of community data, are often presented in the ecological literature with the axes cryptically labeled “Axis 1,” “Axis 2,” and so on, with no explanation as to the concrete meaning, the actual ecological implications, of these coordinate axes. Without such explanations the scatter diagrams yielded by ordinations are uninterpretable. “The primary effort in any PCA should be the examination of the eigenvector coefficients [to] determine which species [or environmental variables] combine to define which axes, and why.”

The great majority of ecological ordinations are done with centered data but this is not always the most appropriate procedure. Sometimes it is preferable to ordinate data in their raw, uncentered form.

It often happens, with real, many-dimensional data, that the second, third, fourth, ... principal axes of an uncentered PCA are roughly parallel with (hence give roughly the same scores as) the first, second, third, ... principal axes of a centered PCA; the equality is never exact....

An uncentered PCA is called for when the data exhibit *between-axes heterogeneity*, that is, when there are clusters of data points such that each cluster has zero (or negligibly small) projections on some subset of the axes, a different subset of axes for each cluster. When an uncentered PCA is done on data of this kind, each of the first few principal axes passes through (or very close to) one of the qualitatively different clusters. Moreover, these axes tend to be *unipolar*. On a unipolar axis all the data points have scores of the same sign, all positive or all negative.

A centered PCA is called for when the data exhibit little or no between-axes heterogeneity and nearly all the heterogeneity in the data is *within-axes heterogeneity* or, equivalently, when the data points have appreciable projections on all axes. With a centered PCA all the principal axes are *bipolar*: on each of them some of the data points have positive scores and some negative scores.

Putting these requirements into ecological terms, it is seen that an uncentered ordination is called for when the quadrats belong to groups having nonidentical lists of common species. A centered PCA is called for when the contrast among the quadrats is less pronounced and their contents differ in degree rather than in kind.

In practice data are often obtained for which it is not immediately obvious whether the between-axes heterogeneity exceeds the within-axes heterogeneity or vice versa. When this happens, it is best to do both a centered and an uncentered PCA. If the between-axes heterogeneity of the data is appreciable, then there will be as many unipolar (or almost unipolar...) axes as there are qualitatively different clusters of data points. Of course, the first axis of an uncentered PCA is automatically unipolar, regardless of whether there is any between-axes heterogeneity. If there is not, then the first axis is merely a line through the origin of the raw coordinate frame passing close to the centroid of the whole data swarm....

[I]n ecological contexts an axis need not be strictly unipolar to suggest the existence of qualitatively different clusters within a body of data.

ATTACHMENT B

MINIMUM VARIANCE CLUSTER ANALYSIS

Excerpts from *The Ordination of Ecological Data: A Primer on Classification and Ordination*, by E. C. Pielou, 1984, John Wiley & Sons, New York.

INTRODUCTION

[T]he data matrix has s rows, respresenting species, and n columns, representing quadrats. The (i, j)th element of the matrix represents the amount of species i (for i = 1, ..., s) in quadrat j (for j = 1, ..., n). We wish to classify the n quadrats by *clustering* or, as it is also called, agglomeration.

To begin, each individual quadrat is treated as a cluster with only the one quadrat as member. As the first step, the two most similar clusters (i.e., quadrats) are united to form a two-member cluster. There are now (n – 1) clusters, one with two members and all the rest still with only one member.

Next, the two most similar of these (n – 1) clusters are united so that the total number of clusters becomes (n – 2). The two clusters united may be single quadrats (one-member clusters), in which case two of the (n – 2) clusters have two members and the rest one. Or else one of the two clusters united with another may be the two-member cluster previously formed; in that case one of the (n – 2) clusters has three members and the rest one.

Again, the two most similar clusters are united. And again and again and again. The process continues until all the n original quadrats have been agglomerated into a single all-inclusive cluster.

Certain decisions need to be made before this process can be carried out. The questions to be answered are:

1. How shall the similarity (or its converse, the dissimilarity) between two individual quadrats be measured?

2. How shall the similarity between two clusters be measured when at least one and possibly both clusters have more than one member quadrat?

Both these questions can be answered in numerous ways. First, to answer question 1. [G]iven n quadrats and s species, the data can be portrayed, conceptually, as n points (representing the quadrats) in an s-dimensional coordinate frame. Therefore, one possible way of measuring the dissimilarity between two quadrats is to use the *Euclidean distance*, in this s-space, between the points representing the quadrats. The coordinates of the *j*th of these n points are (x_{1j}, x_{2j}, ..., x_{sj}). This records the fact that quadrat *j* contains x_{1j} individuals [or, for example, biomass or areal cover] of species 1, x_{2j} individuals of species 2, ..., and x_{sj} individuals of species *s*.

The distance in s-dimensional space between the *j*th and *k*th points, denoted by *d*(*j*, *k*), is therefore,

$$d(j,k) = \sqrt{(x_{1j} - x_{1k})^2 + (x_{2j} - x_{2k})^2 + \ldots + (x_{sj} - x_{sk})^2} = \sqrt{\sum_{i=1}^{s} (x_{ij} - x_{ik})^2}.$$

This is simply an extension to a space of *s* dimensions of the familiar result of Pythagoras's theorem....

Next for question 2, on how to measure the dissimilarity (now distance) between two clusters when each may contain more than one point (i.e., quadrat): the different ways in which this can be done are the distinguishing properties of the first three clustering methods described in the following[—nearest-neighbor clustering, farthest-neighbor clustering, and centroid clustering].

MINIMUM VARIANCE CLUSTERING

Before going into details, it is necessary to define the term *within-cluster dispersion*....

[T]he within-cluster dispersion of a cluster of points is defined as the sum of the squares of the distances between every point and the centroid of the cluster.

CHOOSING AMONG CLUSTERING METHODS

Minimum Variance Clustering

This is a useful technique when there is reason to suspect that some (or all) of the quadrats belong to one or more homogeneous classes. For example, suppose data had been collected by sampling, with randomly placed quadrats, a rather heterogeneous tract of forest and scrub. One might be uncertain whether all the quadrats should be thought of as unique or whether, on the contrary, they formed several distinct classes with all the quadrats in any one class constituting a random sample from the same population. In the former case, every node in a clustering dendrogram is interesting and reveals (it is hoped) "true" relationships among dissimilar things. In the latter case the first few fusions do no more than unite groups of quadrats that are not truly distinct from one another; the differences among the quadrats within such a group are due entirely to chance, and the order in which they are united is likewise a matter of chance.

With minimum variance clustering it is possible to do a statistical test of each fusion in order to judge whether the points (or clusters) being united are homogeneous (replicate samples from a single parent population) or heterogeneous (samples from different populations). This is equivalent to judging, objectively, the “information value” of each node in a dendrogram. Thus if the lowermost nodes represent fusions of homogeneous points or clusters, they have no information value; obviously, it is useful to distinguish them from nodes representing the fusions that *do* convey information about the relationships among the clusters and about their relative ecological “closeness.” The reader is referred to…Orlóci (1978, p. 212) for instructions on how to do the test….

Minimum variance clustering…tends to give clusters of fairly equal size. If a single data point is equidistant from two cluster centroids and the clusters do not have the same numbers of members, then the data point will unite with the less populous cluster (proved in Orlóci, 1978). The result is that, as clustering proceeds, small clusters acquire new members faster than large ones and chaining is unlikely to happen. This is a great advantage when clustering is done to provide a descriptive classification, for mapping purposes, for instance. Of course, it does not follow that a nicely balanced dendrogram gives a truer picture of ecological relationships than a straggly one.

STATISTICAL METHOD FOR MINIMUM VARIANCE CLUSTER ANALYSIS

Excerpt from *Multivariate Analysis in Vegetation Research*, by L. Orlóci, 1978, W. Junk, The Hague.

A[n] appropriate method [for testing significance in sum of squares clustering]…performs a test on the hypothesis that in fusion of any two (A, B) of g groups to form group (A, B), the increase in the variance of the fusion group does not exceed what could be expected if A and B were random samples from two normal populations with equal variance. The null hypothesis is rejected at α probability, and A is not fused with B, if the ratio

$$F = \frac{Q_{AB}}{Q/(N-g)}$$

exceeds $F_{t;1,N\text{-}g}$, the t probability point of the F distribution with 1 and N-g degrees of freedom. In these expressions, Q_{AB} is the increment in the sum of squares due to fusion of A and B, $Q = Q_1 + \ldots + Q_g$, the total within group sum of squares in the g groups; $N = N_1 + \ldots + N_g$, the total number of quadrats in the sample; and

$$t = 1 - (1 - \alpha)^{1/[g(g-1)/2]}.$$

Should $F < F_{t,1,N-g}$ hold true, A and B would be fused.

Appendix O
Work Plan Rationale and Data Quality Objectives

P_4 Production, LLC

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SOUTHEAST IDAHO MINE-SPECIFIC
SELENIUM PROGRAM

Comprehensive Site Investigation

Sampling and Analysis Plan—Final

April 2004

Prepared by

2353 130th Avenue N.E., Suite 200
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This Sampling and Analysis Plan (SAP) for the comprehensive mine-specific site investigations at Enoch Valley, Henry, and Ballard mines describes general environmental investigation activities and procedures, including quality and health and safety procedures, which P_4 Production will use to conduct the site investigations (SIs) under their Southeast Idaho Mine-Specific Selenium Program. The SAP is organized into three parts:

- Part 1—Program Field Sampling Plan (PgmFSP; to be supplemented with appropriate mine-specific Project FSPs or PjtFSPs);
- Part 2—Program Quality Assurance Plan (PgmQAP); and,
- Part 3—Program Health and Safety Plan (PgmHSP).

The PgmFSP references a brief program background and summarizes the objectives of the comprehensive mine-specific SIs (i.e., program objectives are inclusive of all three mine's objectives). Mine-specific objectives can be found in their respective project-specific work plan (PjtWP). The PgmFSP describes tasks and subtasks by environmental medium that will be undertaken and presents procedures for sample collection, handling, and analysis for the entire program. The PgmFSP is designed to be used in conjunction with the appropriate mine-specific PjtFSPs and PjtWPs for the comprehensive mine-specific SIs at P_4 Production's Enoch Valley, Henry and Ballard mines.

The PgmQAP describes program-specific data requirements and standard operating procedures for the measurement of field parameters and sample collection for laboratory analysis. It also presents quality assurance (QA) and quality control (QC) procedures to assure that the data are precise, accurate, representative, comparable, and complete.

The PgmHSP describes health and safety procedures to be followed by the field teams to assure that all fieldwork is conducted safely and in accordance with the requirements of the United States Department of Labor's Mine Safety and Health Administration as well as their Occupational Safety and Health Administration.

The objectives of the comprehensive SI sampling effort for each of the three mines were formulated in accordance with the data quality objectives process documented in Section 3.0 of each mine-specific PjtWP. As a general objective, the data collection process will be focused on that information which is necessary to evaluate and select a removal action alternative in the EE/CA process. The amount of such data to be collected will be what is sufficient to conduct such evaluation and selection. The combined or comprehensive program sampling objectives are described in Section 3.0 of the PgmFSP and the mine-specific sampling objectives are described in detail in Section 3.3 of the three PjtWPs.

The SAP will serve as the guidance manuals for the comprehensive mine-specific site investigation field efforts. Therefore, each team will have one copy of this document at all times when in the field. Each subcontract laboratory is also required to maintain a copy of this plan to be used as reference when conducting work supportive of the comprehensive SIs.

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SOUTHEAST IDAHO MINE-SPECIFIC
SELENIUM PROGRAM

Comprehensive Site Investigation

Program Field Sampling Plan—Final

April 2004

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NOTE:

Section 3.0 has been reproduced here. For the entire Sampling and Analysis Plan, please review the original document.

3.1 DATA QUALITY OBJECTIVES

DQOs for the Enoch Valley Mine site investigation are specified below in accordance with USEPA's seven-step process:

- Step 1: State the Problem;
- Step 2: Identify the Decision;
- Step 3: Identify the Inputs to the Decision;
- Step 4: Define the Boundaries of the Study;
- Step 5: Develop a Decision Rule;
- Step 6: Specify Tolerable Limits on Decision Errors; and,
- Step 7: Optimize the Design for Obtaining Data.

The goal of the process is to ensure that sufficient amounts of data that are necessary for selection of a removal action are available at the conclusion of the site investigation.

3.1.1 Step 1: State the Problem

Several COPCs, including selenium, are leaching, at concentrations of potential concern, from waste rock into surface water systems, specifically mine pits, stock ponds, dump seeps, springs and streams. Peak selenium concentrations are observed at the start and height of spring runoff. Thus, it seems likely that much of the transport of contamination to surface water bodies may be occurring via surface runoff or shallow interflow. However, transport may be occurring via groundwater. This hypothesis needs to be tested. Surface water and sediment sampling to date has served to help identify potentially affected groundwater systems. Geology needs to be considered because structure is likely to control such systems.

Upon conclusion of the interim surface water and sediment investigation of 2002-03, we now have an excellent idea of where the problem areas exist. An additional search for surface expressions of groundwater will be undertaken as part of the geology and groundwater investigation. Any additional stations identified in this activity will be sampled to enhance our understanding of the local groundwater and surface water systems. Additional sampling of surface water and associated sediments will help to further quantify seasonal and annual variability in water and sediment quality. It will also provide adjunct data to those to be collected under the groundwater and ecological investigations. Additional soil investigation is needed at this time to help delineate the extent of downstream and pond-side contamination by characterizing the quality of riparian soils. Spring flows will be measured to determine the nature of the aquifers feeding them. Dump seep flows will be measured to allow engineering evaluations of removal alternatives.

An inventory of existing groundwater wells within a three-mile radius of the mine will be performed and all such wells—industrial, agricultural, or domestic—will be sampled, as practicable. After compiling as much existing information as possible, installation of additional monitoring wells may be performed and these wells sampled. The combined analysis of available geologic information with information from existing wells will allow delineation of groundwater flow systems either underlying or near the mine. The delineation will include location of probable recharge and discharge areas. Assessing the geologic controls for discharge areas (seeps and springs) is of primary importance. Monitoring wells may be constructed where needed to provide information on selected groundwater flow systems where additional detail is needed on the geologic control for groundwater movement and/or the flow direction. Any new wells will be sampled and included in the monitoring network.

Per IDEQ's regional risk assessment, air itself is not a transport pathway of potential concern, nor is inhalation an exposure route of potential concern. Thus, the need for our air investigation is limited to obtaining existing local and regional climatologic information. Most if not all of such information sources have already been identified by IDEQ. Seasonal information appears to be germane as contaminant concentrations vary proportionally to runoff. A similar climate-dependent variability on an annual basis is expected.

The leaching of contaminants from waste rock is also expressed via plant uptake from what amounts to unweathered seleniferous soil. Since IMA's regional investigation of 1998 we have known that vegetation growing upon waste rock dumps, even those dumps covered with a foot or two of reclaimed topsoil, may have more selenium, on average, than is desirable. Soil and vadose zone combine, with vegetation, to control recharge to groundwater flow systems. Thus, the soil investigations will contain a water balance component for waste rock dumps.

With regard to biota, IDEQ's regional risk assessment, and IMA's preliminary risk assessment, indicate no threat to human health. However, IDH has issued a consumption advisory for one stream in the region—East Mill Creek. This creek is in no way associated with P_4 Production, but such advisory has the potential to call attention to the entire region. We understand that IDH is also considering a health advisory for elk consumption on the Fort Hall Reservation. P_4 Production has not yet seen Reservation-specific elk quality data, but, given that 1998 IMA data show vegetation quality at Gay Mine to be generally not as bad as that at the rest of the mines to the east, it would be a surprise to see higher concentrations of selenium in Reservation elk. Despite an IMA risk assessment that pronounced the beef safe for human consumption, the IMA's Henry Mine beef grazing study concluded with the USFSIS condemning two of fifteen steer carcasses that were slightly above an interim and undocumented standard imposed by the agency. Considering such actions, there is a need for a refined human health risk assessment. P_4 Production shall focus on a single maximally exposed population of individuals: phosphate miners who are also cattle ranchers, elk hunters, and trout fishermen.

While the IDEQ's regional risk assessment demonstrates no significant adverse impact to non-human organisms on a population level, the agency has let it be known that it wishes ecological health risk assessments be performed on a mine-specific basis and to assess risks to local populations. CERCLA regulations say little about ecological health risk assessment. In fact, only one sentence addresses the topic, 40 CFR §300.430(e)(2)(i)(G):

> Environmental evaluations [e.g., ecological health risk assessments] shall be performed to assess threats to the environment, especially sensitive habitats and critical habitats of species protected under the Endangered Species Act.

Given the focus on habitat, it is inappropriate to direct the ecological health risk assessment to individuals. Rather, the focus needs to be on local populations or communities. From a wide array of indicator species, the IDEQ's risk assessment identified three species and one group of species that failed to screen out: the song sparrow, the mallard, the black-tailed jackrabbit, and fish. In addition to these organisms, IDEQ has identified four species that each represent a sensitive feeding guild or dwell within riparian zones—a habitat of potential concern to the agency. These organisms, plus elk, will be our ecological receptors or potential concern.

An agricultural health risk assessment will also be performed to determine threats to livestock grazing on or below waste rock dumps. Significant economic losses have occurred at some non-P_4 Production mines.

A three-part conceptual exposure site model for Enoch Valley Mine has been derived from IDEQ's regional conceptual exposure models and the results of their AWHHERA. The three-part refined model is presented in Figures 3-1, 3-2, and 3-3 for the human health, ecological health, and agricultural health perspectives, respectively. The graphics depict the exposure pathways of potential concern, the exposure routes of potential concern, and the receptors of potential concern.

FIGURE 3-1
HUMAN HEALTH CONCEPTUAL EXPOSURE SITE MODEL
ENOCH VALLEY MINE SITE INVESTIGATION

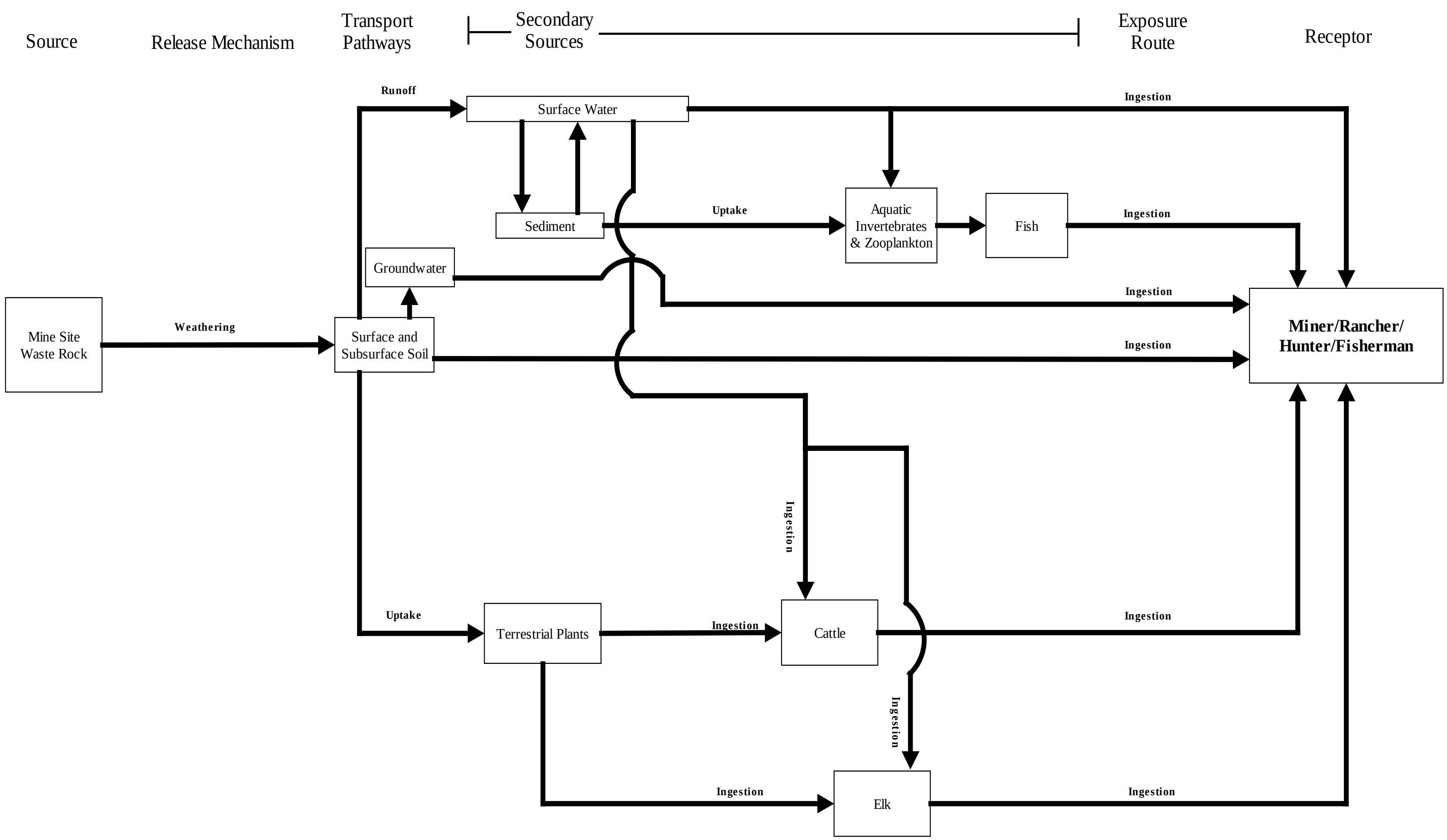


FIGURE 3-2
ECOLOGICAL HEALTH CONCEPTUAL EXPOSURE SITE MODEL
ENOCH VALLEY MINE SITE INVESTIGATION

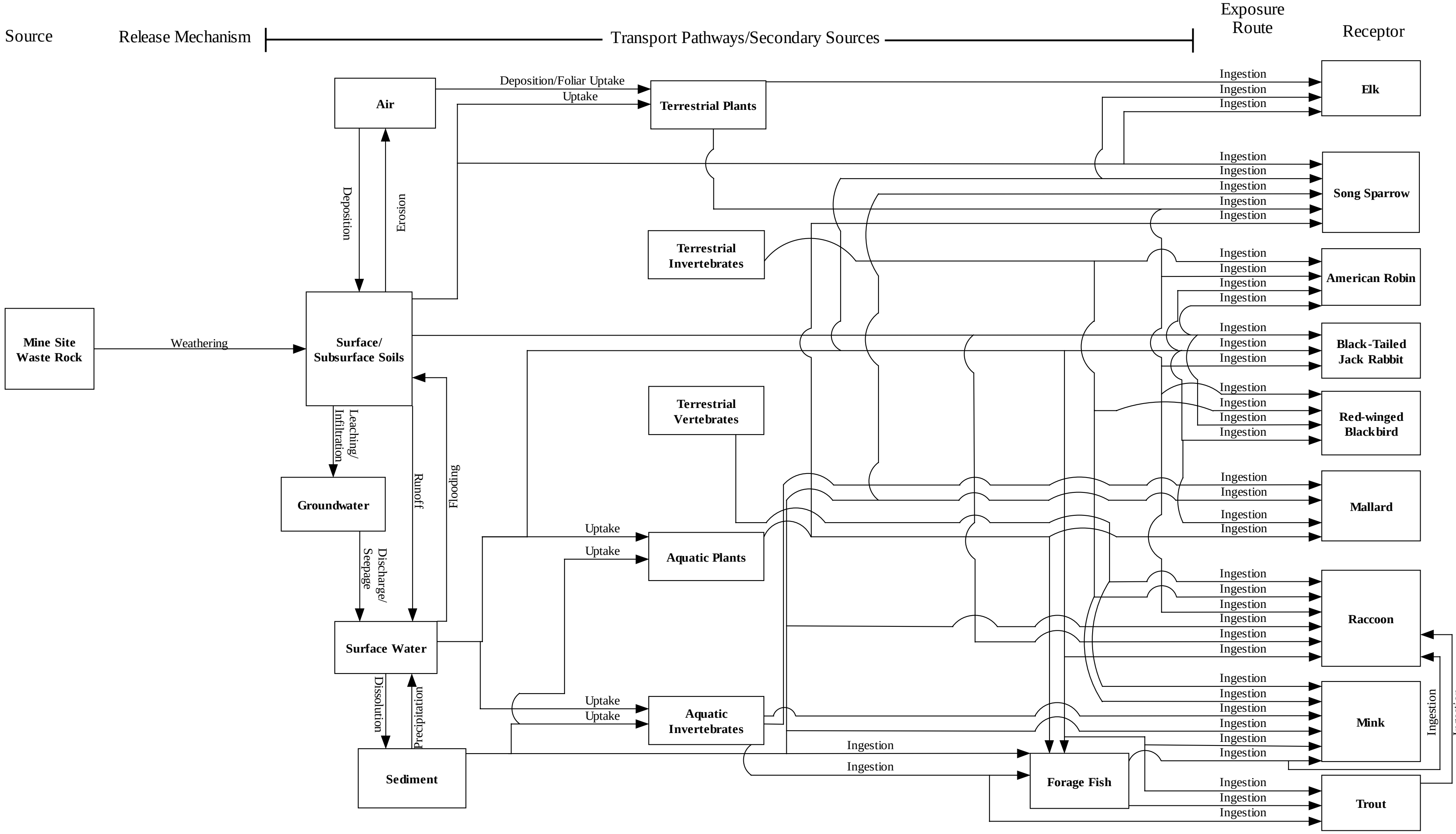
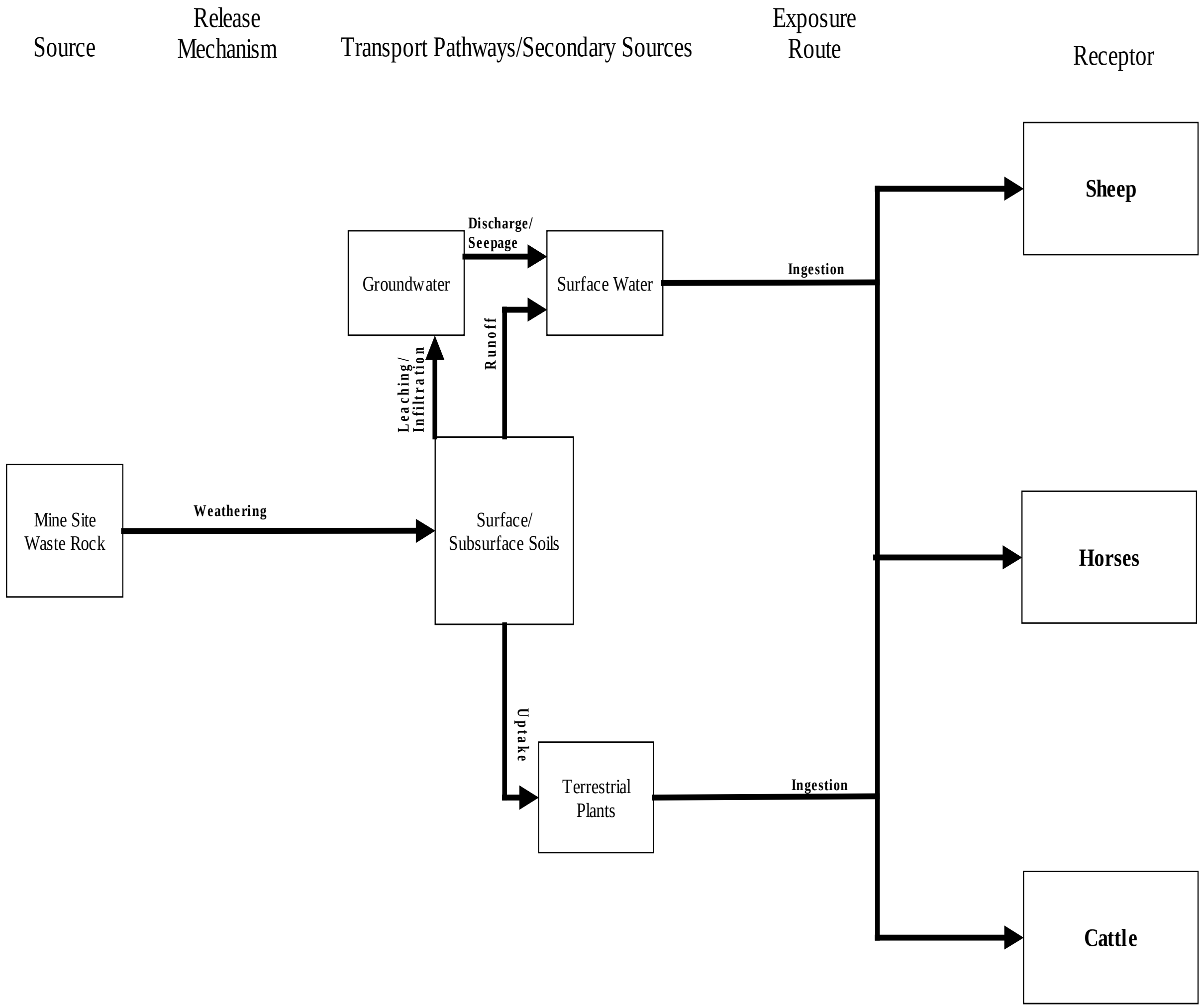


FIGURE 3-3
AGRICULTURAL HEALTH CONCEPTUAL EXPOSURE SITE MODEL
ENOCH VALLEY MINE SITE INVESTIGATION



The COPCs vary slightly with environmental medium and are discussed below in Section 3.2.2.

The biotic media data needs are as follows:

- Assess stream habitat to evaluate its quality to support a fish population;
- Characterize fish tissue quality (both trout and forage fish), if present, to determine potential impacts to the fish populations (as well as to the humans who consume the trout);
- Assess pond, wetland, and non-fish-bearing streams to determine the extent or nature of usage of such habitats (i.e., wildlife watering, livestock watering, or bird utilization);
- Characterization of the riparian soil and vegetation quality at streams, seeps, springs, ponds, wetlands, and reservoir deltas;
- Evaluate a suitable seed mixture that provides desirable traits for reclamation—erosion control, cover, and future grazing potential;
- Identification and location of known selenium absorber species (e.g., plants of the genera *Aster* and *Grindelia*, so that potential control measures can be studied); and,
- Evaluate livestock use of reclaimed mine dumps by the creation of a veterinary toxicology panel to make recommendations.
- Characterization of the change in quality of vegetation from waste rock dumps onto adjacent rangeland in areas susceptible to mass wasting.

3.1.2 Step 2: Identify the Decision

Are the environmental media on or near P_4 Production's Enoch Valley Mine elevated in selenium concentration and, if so, are the elevated selenium concentrations attributable to the Enoch Valley Mine? If elevated selenium (or other targeted analyte) is attributable to P_4 Production's past or current activities at the mine, are such levels: in compliance with State and Federal chemical-specific ARARs; in excess of IDEQ's Area Wide Risk Management Plan Removal Action Levels; or posing a threat to human or environmental or agricultural health that requires a removal action (as defined per CERCLA) to mitigate such threat?

In accordance with USEPA (1988), the objective of this site investigation:

> [I]s not the unobtainable goal of removing *all* uncertainty, but rather to gather information sufficient to support an informed risk management decision regarding which [removal option] appears to be most appropriate…. The appropriate level of analysis to meet this objective can only be reached through constant strategic thinking and careful planning concerning the essential data needed to reach a [removal option] selection decision. As hypotheses are tested and either rejected

> or confirmed, adjustments or choices as to the appropriate course for further investigations and analyses are required. These choices, like the [removal option] selection itself, involve the balancing of a wide variety of factors and the exercise of best professional judgment."

(In the above quote "removal option" was appropriately substituted for such terms as "remedial alternative" and "remedy.")

It is to be noted that the site investigation is *not* a design investigation. In short, the investigation is expected to be a phased effort interacting with the engineering evaluation/cost analysis (EE/CA), and will be done to the degree necessary to provide sufficient information to select a removal option. P_4 Production will identify additional or refined data needs—using risk assessment models, decision analysis tools, and value-of-information methods—with the input or approval of the agencies, which, in the case of Enoch Valley Mine might be a joint decision with IDEQ and USFS (J.B. Reese, USFS [Letter to B. Geddes, Monsanto] December 20, 2001).

Decision analysis modeling will be used to facilitate the selection of an optimal removal action alternative. Criterium DecisionPlus (CDP) software will be used (InfoHarvest, 1999). The general structure of the model (the hierarchy) is expected to be very similar to that shown in Figure 3-4.

CDP provides two options for rating alternatives; P_4 Production will use the SMART option (Simple Multi-Attribute Rating Technique). The full pairwise method of rating criteria and subcriteria will be used initially; taking care to ensure that consistency ratios stay low and insignificant. CDP provides two options for valuating the criteria hierarchy—weights and tradeoffs. While P_4 Production may initiate the valuations with weights, the ultimate valuations will be based on (or at least validated with) quantitative tradeoffs to ensure that the model is reasonable. The choice to impose nonlinearity on any value functions will be determined subjectively and by consensus. Differences in values between stakeholders will be accounted for with either separate models or through probabilistic weighting of criteria to describe such differences. MWH is working with InfoHarvest to see if they can provide a functional way to account for such differences in scores of alternatives against subcriteria by means of custom discrete probability distributions. This would allow stakeholders to be polled and the resulting distribution of scores to be entered into the model without having to replicate the model for each perceived difference.

CDP generates a decision score for each alternative (or a probability distribution of decision scores if probabilistic scoring of alternatives is done). For deterministic applications, the optimal alternative—the one with the highest decision score—is identified. For probabilistic applications, the optimal alternative is defined as the one that has the highest probability of being the highest scoring alternative. The model can be subjected to contribution analysis—which reveals where the overall decision score is coming from—and to sensitivity analysis—which reveals whether the decision is robust or sensitive to a particular criterion or subcriterion. A sensitive decision is a flag to review and refine the decision model. These built-in tools can be used to conduct effective value-of-information analyses to identify the need for any additional data collection or evaluation.

Figure 3-4. Example Criterium DecisionPlus Model. This shows, in columns from left to right, the decision goal, the decision criteria, the decision subcriteria, and the alternatives. Criteria are as defined in regulation. Subcriteria are as defined in guidance.

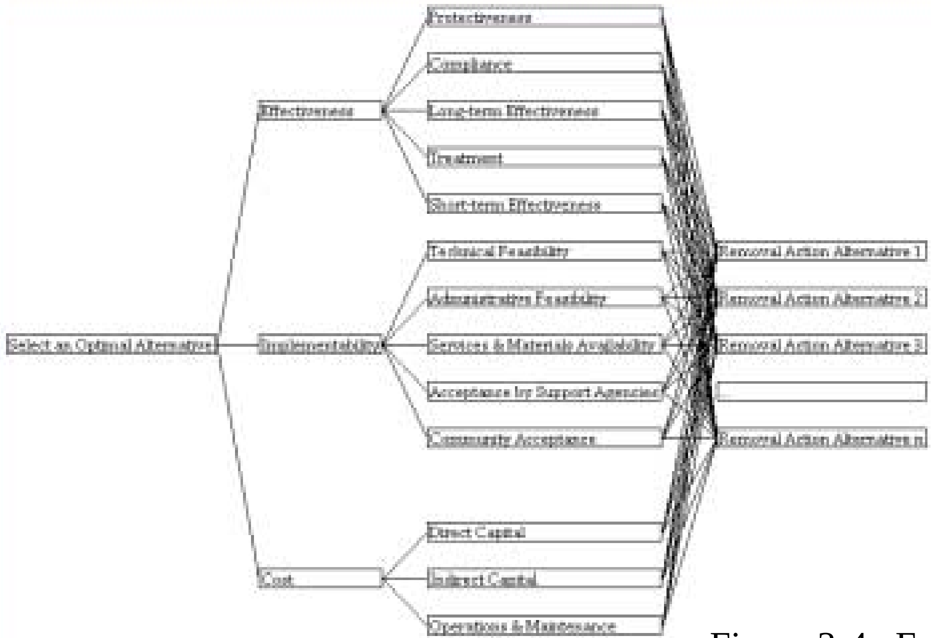


Figure 3-4. Example Criterium DecisionPlus Model

The overall effect of decision analysis modeling is to support the decision-making process by clarifying the process, identifying information needs, documenting the process to make it defensible to those who are not involved today but will be interested tomorrow, and to promote consensus among stakeholders. The decision-making agencies will not, of course, be bound by the results of the modeling.

Alternative removal action options will be defined in the EE/CA process. At that time alternative-specific decision statements can be formulated.

3.1.3 Step 3: Identify the Inputs to the Decision

Inputs to the decision will consist of a combination of sampling data and modeling estimates. This work plan addresses a comprehensive set of sampling activities, but additional phases of work may be necessary. Primary inputs to removal option selection include compliance and risk thresholds. Compliance thresholds are those standards, requirements, criteria, or limitations that are germane to the contaminants, locations, or actions being addressed. Risk thresholds are hazard indices that have a low probability (e.g., < 5 %) of exceeding unity for a sensitive human or agricultural subpopulation or for a local wildlife or fish population.

An appropriate analytical method for selenium determination in water is available to allow for effective decision-making at a resolution of 0.005 mg/L—perchlorate digestion-hydride generation-ICP spectroscopy. This method used by University of Idaho (project quality assurance laboratory) is considered the most accurate method. The project primary laboratory, ACZ, uses a different method, sodium hydroxide/hydrogen peroxide-hydride generation-AA-spectroscopy, but in round robin evaluations on water standards and common soil samples conducted by the University of Idaho, ACZ performed very well and is thus regarded as functionally equivalent in performance to the University of Idaho. The detection limit for selenium in water is 0.001 mg/L for both laboratories.

It is important that the data not be censored. MWH will request that the laboratories refrain from censoring the data, as is strongly advised by Gilbert (1987). For those desiring to censor the data, which degrades its quality, MWH will present the censoring levels that would result from a strict application of USEPA data validation guidelines. All the information contained in a normal laboratory report will be made available

3.1.4 Step 4: Define the Boundaries of the Study

This work plan sets forth a phased study of between two and three years in duration. Spatially, the study area includes P_4 Production's Enoch Valley Mine and the extent of any significant contamination that has emanated from the mine. Appropriate background areas are included. The study area is anticipated to be well confined to the locations shown in the map presented in Figure 4-1 of the Enoch Valley Mine PjtFSP, *Enoch Valley Mine Sampling Locations*.

For surface water, substantial changes in selenium concentration in affected flowing waters are known to occur seasonally, with higher concentrations observed during spring runoff. Selenium concentrations are thought to vary annually in a manner that is proportional to climatic factors related to runoff. While the data gathered under this plan can be used to evaluate both forms of temporal variability, this plan's primary purpose is not to assess annual variability. For that, a long-term monitoring program may be needed. Groundwater sampling will occur to evaluate seasonal variability.

Surface water and sediment background will be obtained at several stations within the mining district, including stations immediately upstream of the Enoch Valley Mine where possible to define mine-specific background conditions. The mine-specific background will only be used to characterize the background conditions at the portion of the mine associated with the media in question. All known seeps, springs, and streams issuing from the area of the mine or flowing past the mine will be sampled, and characterization will be conducted downstream to the respective delta in Blackfoot Reservoir. All ponds at the mine, whether stock ponds or mine pits, will be further sampled.

The scale of decision making—i.e., the exposure unit—will depend on the type of mine facility or water body. For waste rock dumps, the entire dump is an exposure unit. For mine pits, the entire pit is an exposure unit. For ponds, each pond is an exposure unit. Similarly, each seep is an exposure unit. For streams, any impacted stream will be divided into reaches that will be regarded as exposure units, and such divisions will be dependent on the spatial distribution of the impacts observed. For the reservoir, the delta area is the exposure unit. For groundwater, any affected surface water discharge point is an exposure unit.

The SOW, appended to the EE/CA work plan and PgmQAP, will serve as an administrative boundary of the study.

3.1.5 Step 5: Develop a Decision Rule

Explicit decision rules cannot be formulated at this time, because removal action alternatives have not yet been developed.

The statistical parameters of interest are those needed to define the distributions of values for the variables of interest, because stochastic risk assessment techniques will likely be employed.

For surface water and groundwater, the most germane human health action level is the national selenium drinking water standard under the Safe Drinking Water Act of 0.05 mg/L. However, this standard applies only at the tap, and no drinking water supplies are known or suspected of being contaminated. The IDEQ's Ground Water Quality Rule (IDAPA 58.01.11) also applies.

The relevant ecological health action level for surface water is the chronic water quality criterion for selenium of 0.005 mg/L, which has been adopted by IDEQ as the state's cold-water biota standard. However, empirical data generated by the IMA seem to indicate that this standard is overly strict for flowing-water systems in southeast Idaho. Because of these factors, risk assessment may be used to determine a credible risk based benchmark for the mine. Background surface water quality and wells not impacted by mining will be regarded as background groundwater quality.

For sediments and soils, there is no selenium criterion or standard, so background will be used to determine levels of interest. Specifically, the one-sided lower 95% confidence bound on the 99.9^{th} percentile for each medium will be used to functionally define the upper bound of the background distribution for these media (and for all others). Because there are no established health action levels for these media, such levels will be defined through the risk assessment process. IDEQ is using risk-based action levels to identify areas of a mine site that must be subjected to an EE/CA.

For aquatic biota, there is a selenium criterion for fish tissue that has been unanimously recommended for adoption as an aquatic life criterion by a USEPA review panel (in lieu of the current 0.005 mg/L water quality criterion). This recommended risk-based criterion will be used in the risk assessment activities, however not during screening unless the criterion is recommended. Refer to section 3.1.2 for the decision model. Local background fish tissue quality will be determined from samples obtained at regional background stations.

For terrestrial biota, there is a selenium guideline for vegetation that has been endorsed by the NRC for more than two decades—an MTL for livestock feed of 2 mg/kg. This concentration is regarded as safe for all species of livestock; whereas, the oft-cited concentration of 4 or 5 mg/kg is regarded as a chronic toxicity threshold. Unfortunately, the existing literature tends to be quite sloppy about the moisture basis of selenium concentrations in vegetation. Proper analysis would require all such concentrations be reported on a dry-weight basis, but many appear to be on a wet-weight basis or, for agricultural feed, on as-fed basis, which is somewhere between fresh wet weight and true dry weight. We shall attempt to eliminate this confusion. Background vegetation (and soil) quality will be determined from undisturbed Phosphoria Formation outcrops.

Risk to terrestrial wildlife (see Figure 3-2) will be assessed by means of toxicity reference values per USEPA guidance.

For selenium, measurement detection limits are adequate by more than an order of magnitude for solid matrices. For water, however, such detection limits are at or slightly below (perhaps by a half order of magnitude) the potential action level. Censoring data when the action level and limit of detection are so close can introduce substantial error into the data evaluation (Gilbert 1987) and risk management decision-making processes. Therefore, MWH will request that the laboratory not censor the data in any matrix, although censoring levels will be provided for those interested in knowing them.

3.1.6 Step 6: Specify Tolerable Limits on Decision Errors

As mentioned above in Step 2, the "appropriate level of analysis [and, thus, of controlling decision errors]…can only be reached through constant strategic thinking and careful planning concerning the essential data needed to reach a [removal option] selection decision." Traditionally, Type I errors (the false alarm rate) are controlled at 5%, while Type II errors (the alarm failure rate) are controlled at 20%. The nature of this investigation is sufficiently complex to preclude the ability to calculate exact error rates. Instead, decision analysis tools will be used to determine the sensitivity or robustness of decisions and, in conjunction with value-of-information techniques, to determine the utility of gathering more information. Using a risk assessment procedure—to quantify effectiveness, implementability, and cost—that acknowledges, incorporates, and discloses the effects of uncertainty will facilitate this process.

3.1.7 Step 7: Optimize the Design for Obtaining Data

The outputs of the previous six steps of the DQO process will be used in developing the PjtFSP for the SI at P_4 Production's Enoch Valley Mine. Probabilistic sampling will be used as appropriate, especially to allow for hypothesis testing regarding whether contaminant concentrations change upstream and downstream of the mine—or upgradient and downgradient of the mine, or off or on a waste rock dump—and regarding if and how contaminant concentrations change along longitudinal profiles of key streams. Replicate sampling may be necessary to test these hypotheses.

3.2 WORK PLAN APPROACH

3.2.1 Locations, Frequencies, and Numbers of Samples

According to Green (1979) the objectives derived from the exercise documented in Section 3.1 above place this project into the category of determining "the impact effects, if any, of existing point-source pollution by assessing the spatial pattern of species composition in the adjacent area." More to the point, this is a "pattern and point-source pollution" study. Green's text is focused on biological investigations, so to tailor his recommendations to a contaminated site investigation one must interpret ‘species’ to mean chemical analytes rather than biological species. Green summarizes the components of a pattern and point-source pollution study in Table 3–1.

With regard to the spatial distribution of sampling stations, Green points out that what is needed is many stations on a grid, each with replication. As will be seen in the PjtFSP, the ‘grid’ for stock ponds and the ‘grid’ for dump seeps or springs consists of all known stock ponds and all known dump seeps or springs, respectively. Thus, in both cases the entire known population of facilities is being sampled for surface water, sediment, and riparian soil and vegetation. (No forage fish or salmonids are expected to be found in these water bodies.) Surface water sampling amounts to indirect sampling of groundwater in the case of some ponds, and direct sampling in the case of springs and seeps. Groundwater sampling will, in Phase 1, include all known wells, seeps, and springs within a three-mile radius of the mine. Thus, the entire known population of such sampling stations will be sampled.

In the case of streams, sampling on a grid as it is usually envisioned is not practicable; however, a ‘schematic grid’ has been developed in the sense that potential sampling stations on all streams within the Southeast Idaho Phosphate Resource Area have been systematically identified and inventoried by IMA (1998). These stations were located on all streams that are downstream of a phosphate mine, with stations placed upstream and downstream of mines, where possible, and upstream and downstream of the confluence of streams, where necessary, to differentiate contributions from two watersheds (and, at times, two or more mines). The result is a thorough schematic grid of the Resource Area that was first synoptically sampled, with regard to Enoch Valley Mine and P_4 Production’s other two mines, in 2002-03. As described in Section 4.0 of the PjtFSP, P_4 Production will synoptically sample—for surface water, sediment, forage fish, salmonid, riparian soil, and riparian vegetation—that portion of the grid that is directly and indirectly relevant to their Enoch Valley Mine.

Table 3–1. Sampling and Analysis Properties for a Pattern and Point-Source Pollution Study (modified from Green, 1979)

Objective	Property	Notes
Spatial chemical pattern	Information	The focus of this investigation
Natural environment spatial pattern	Noise	Background or control conditions in the absence of impact
Pollutant	Exists	Selenium, et al.
Distribution of samples in space	Many stations on a grid, each with replication	See discussion below
Temporal chemical change	Noise	See discussion below
Natural environmental temporal change	Noise	Background or control conditions in the absence of impact
Distribution of samples over time	At least two different times	At least two different times

In applied compliance investigations such as this one, sample replication is rarely done. As Green (1979) points out, “Differences among [stations] can only be demonstrated by comparison to differences within [stations]”; thus, sample replication in space and time are needed. In absence of such replication, the ability to conduct meaningful statistical analyses is usually forgone and the only evaluation one can do with any credibility, as limited as it is, is a simple plot of the data accompanied by guesses of meaning.

With regard to temporal chemical change, Green indicates this is merely noise, but in this particular case the information is rather more relevant. This is because a better understanding of seasonal and annual variability will be of use during the EE/CA in evaluating diverse alternatives ranging from institutional controls (Are they needed only during a certain season because of predictable temporal variability?) to treatment (Could operations be confined to a certain season because of predictable temporal variability?). Given that aquatic matrices are most susceptible to temporal variability, the additional surface water sampling conducted under this plan will help in further quantifying such variability. Groundwater sampling will be done such that selected stations—whether wells, seeps, or springs—will be sampled at least twice, during periods of seasonal high and low water table. We assume that there are no substantial seasonal changes in riparian soil and vegetation quality, or in waste rock dump soil and vegetation quality, so are only sampling these media once. Fish, both forage fish and salmonids, will also only be sampled once. As forage fish may have somewhat higher selenium whole-body concentrations during runoff than during baseflow, salmonid muscle selenium concentrations are highly significantly greater during runoff; thus, this one-time sampling event will be conducted during runoff. Salmonids will be analyzed for both whole-body and muscle, with the exception of the QA/QC analyses, which will only be conducted for whole-body.

3.2.2 Contaminants, Receptors, and Pathways of Potential Concern

Three key elements to the conceptual understanding of any contaminated site are the contaminants, receptors, and exposure pathways of potential concern. Identification of contaminants, receptors, and pathways of potential concern is an element of the project scoping process that is subject to iterative refinement in the risk assessment process.

IDEQ issued the *Final Area Wide Human Health and Ecological Risk Assessment* report in 2002 and a *Final Draft Area Wide Risk Management Plan* in 2003. The risk assessments that have been performed by IDEQ and IMA, and the IDEQ risk management plan are used to identify receptors of potential concern, and to identify which exposure pathways may be operable in conveying significant adverse doses of contaminants to the receptors, and thus rendering such pathways of potential concern. The agency's reports, the IMA risk assessment, and the results of P_4 Production's interim surface water and sediment investigation are used to develop the information presented below.

Contaminants of Potential Concern

Based on the *Final Draft Area Wide Risk Management Plan,* the IDEQ recommended the following list be regarded as contaminants of concern for future mine-specific investigations for all media, except surface water and vegetation:

- Selenium,
- Cadmium,
- Chromium,
- Nickel,
- Vanadium, and
- Zinc.

For surface water and vegetation, IDEQ recommended that the above list exclude chromium, nickel and vanadium.

IDEQ's recommended contaminants of concern list described above was further evaluated by MWH. Considerable region-specific data are available from recent investigations conducted by IMA, and these can be supplemented by site-specific data available for P_4 Production's three mines. These data, in conjunction with IDEQ's conclusions from their area wide risk assessment and risk management plan, are used to identify a focused set of contaminants of potential concern.

Based on the agency's recommendation, historical site-specific data, the interim surface water and sediment investigation data, and considering co-dependent media and analyte interactions, MWH revised the recommended list and created the site-specific contaminants of potential concern (COPC) list by the following rationale:

- Nickel and vanadium were added to the COPC list for surface water because they were retained for sediment and because there is no additional laboratory cost for doing so.

- Upon reviewing the results of P_4 Production's mine-specific surface water and sediment investigations and past IMA results, we fail to see chromium concentrations of any true concern. An occasional sediment sample will exceed a preliminary risk-based benchmark concentration, but this preliminary benchmark assumes, unrealistically, that one-seventh of the chromium is present in the toxic hexavalent state. Trivalent chromium, the typical form found in the environment, is virtually non-toxic; in fact, it is a mineral supplement widely used in high doses. Hexavalent chromium is unstable under environmental conditions and is encountered as a contaminant under conditions where large quantities of the hexavalent form is used in an industrial process. IDEQ is unwilling to drop chromium as a COPC at this time. Given this, chromium will be analyzed in groundwater, sediment, and soil despite P_4 Production's objections.

- Copper was added to the soil and vegetation based upon the interactions of copper, molybdenum, and selenium.

- Molybdenum was added to the soil and vegetation COPC list because concentrations of potential concern have been observed in vegetation growing on the Enoch Valley Mine waste rock dump (but at a frequency and relative magnitude less than selenium, and in only a subset of locations having elevated selenium).

Mine-specific contaminants of concern should not be designated until after finalization of a mine-specific risk assessment. Thus, we shall refer to the list as COPCs. The resulting COPC list for P_4 Production's Southeast Idaho Mine-Specific Selenium Program is summarized below in Table 3–2, *Contaminants of Potential Concern*.

TABLE 3–2
CONTAMINANTS OF POTENTIAL CONCERN

Analyte	Surface Water	Sediment	Fish (forage & salmonid)	Groundwater	Surface Soil	Vegetation
cadmium	X	X	X	X	X	X
chromium		X		X	X	
copper					X	X
molybdenum					X	X
nickel	X	X	X	X	X	
selenium	X	X	X	X	X	X
vanadium	X	X	X	X	X	
zinc	X	X	X	X	X	X

Receptors of Potential Concern

The IMA and IDEQ have evaluated receptors for both human and ecological health. Evaluations for agricultural health of livestock have also been conducted. On the basis of these efforts a focused list of receptors of potential concern have been identified (unless conditions are discovered well outside the scope of IDEQ's previous assessment). From a human perspective the sole maximally exposed receptor of potential concern, for chronic exposure, is a phosphate miner who happens to run a ranch and hunt and fish locally and consume his game meat and trout. For acute exposure, the sole receptor of concern is an elk hunter who consumes elk liver.

Additional discussion of the risk to children will be provided in the risk assessment to assure the public that these individuals were considered.

From an ecological perspective, the receptors of potential concern are American robin, red-winged blackbird, raccoon, mink, mallard ducks, song sparrow, black-tailed jackrabbit, elk, and fish (i.e., both forage fish and trout). These are indicator species occupying different niches or trophic levels within habitats known to be contaminated by selenium releases from phosphate mining. Not all of these organisms will be carried through the entire assessment. Because of the sensitive nature of the stream and reservoir habitats, fish will be carried through. Because of its importance as a recreational species, elk will be carried through. With regard to the remaining seven species, preliminary screening calculations will be used to identify the three most at risk and those three will be carried through. From an agricultural perspective, the receptors of potential concern are sheep, horses, and cattle. These species have grazed mining-caused seleniferous pastures at various mines throughout the mining district. However, horses are not known to graze upon Enoch Valley Mine at present. Currently, sheep and cattle grazing at Enoch Valley Mine is not permitted, but has been known to happen due to minor trespass.

<u>Exposure Pathways of Potential Concern</u>
For human health, the pathways of potential concern are all associated with ingestion. For chronic exposure the ingestion pathways of potential concern are:

- Groundwater,
- Surface water,
- Trout,
- Soil (i.e., waste rock), and
- Beef.

For acute exposure, the ingestion pathway of potential concern is ingestion of venison from elk.

From an ecological perspective, all exposure pathways of potential concern are again associated with ingestion. For the mallard:

- Aquatic invertebrates,
- Sediment,
- Aquatic vegetation, and
- Surface water.

For the song sparrow the pathways are the same as the mallard (excluding aquatic invertebrates), plus the ingestion of terrestrial vegetation and soil. For the black-tailed jackrabbit and the elk:

- Terrestrial vegetation,
- Soil, and
- Surface water.

The American robin and the red-winged blackbird are the same pathways as the black-tailed jackrabbit and the elk except with the addition of terrestrial invertebrates. For trout:

- Aquatic invertebrates,
- Forage fish, and
- Surface water.

For the raccoon:

- Terrestrial plants,
- Terrestrial invertebrates,
- Terrestrial vertebrates,
- Soil, and
- Surface water.

And for mink:

- Terrestrial invertebrates,
- Terrestrial vertebrates,
- Soil, and
- Surface water.

Organismal-level risk assessment evaluations will be done based on the information presented above. This is entirely appropriate for human health, and for agricultural health, but inappropriate for ecological health, because the correct ecological assessment endpoints are at the local population or community levels. Thus, ecological risk assessment performed at the organismal level is, by it's very nature, a screening exercise—e.g., if no cause for concern is demonstrated, one can generally assume the absence of a problem, but an inability to screen a species does not mean that a problem exists; rather, it usually means there is a need for refinement of the assessment.

Organismal-level risk assessment evaluations will be conducted for human health and agricultural health. Risk assessment activities will address local populations at or near the site as provided by USEPA guidance. Individual risk may be considered in the screening process for ecological health.

An ecological assessment can be meaningfully refined either by undertaking a local population- or community-level assessment, or by undertaking laboratory or field studies. The IMA has done both. Some population-level assessment models were prepared for bird species, bird field studies supported by laboratory analyses have been performed, several studies on cutthroat trout have been conducted, a study of elk has been conducted, and a fairly extensive characterization of selenium concentrations in various biotic media has been carried out.

In addition to evaluating threats to local populations of species, threats to sensitive habitats will also be considered. There are no known critical habitats of endangered or threatened species in the area of Enoch Valley Mine.

The issues mentioned here will be taken into account when refining the conceptual understanding of the Enoch Valley Mine by updating the contaminants, exposure pathways, and receptors of potential concern.

3.3 INVESTIGATION OBJECTIVES

The objectives of the SI for P_4 Production's Enoch Valley Mine were formulated in accordance with the DQO process documented in Section 3.1 of the Enoch Valley Mine Work Plan. As a general objective, the data collection process is to provide those data that are necessary to evaluate among and select a removal action alternative in the EE/CA process. The amount of such data to be collected will be what is sufficient to conduct such evaluation and selection. The specific work breakdown structure for the SI is presented in Table 3-3. The sampling objectives are as follows:

1. Determine if there are any past or current irrigation canals that could affect water flow on or near the mine.

2. Characterize surface water and sediment quality to support the characterization of riparian soil and vegetation quality and fish tissue quality, as well as to further quantify annual variability.

3. Compile local and regional climatologic data that may be pertinent to the characterization of annual and seasonal changes in runoff.

4. Compile and review available local and regional hydrogeologic data—e.g., published and unpublished hydrogeologic reports, geologic maps, cross sections, mine maps, and anecdotal information from mine geologists and managers—so as to make maximum use of such information.

5. Conduct a thorough well inventory within a three-mile radius of the mine to document locations and construction specifications of all mine production, agricultural, and domestic wells that could be relevant groundwater sampling stations.

6. Conduct a spring and seep survey on the mine and within the vicinity during runoff to identify any additional surface expressions of groundwater for characterization.

7. Measure flows of springs and dump seeps during runoff. For dump seeps the purpose is to evaluate alternatives. For springs the purpose is to characterize the nature of the aquifer and thus must occur over time to determine whether flows are continuous or seasonal.

8. Sample all relevant groundwater stations—including existing wells, springs, and seeps—for characterization of groundwater quality.

9. Install additional wells, if necessary, to address data gaps related to identified flow paths associated with potential sources, or possibly to confirm critical components of the updated conceptual hydrogeologic site model.

10. Conduct a water balance to help understand the hydrologic system of the mine.

11. Characterize the quality of riparian zone soil at streams, ponds, seeps, springs, and wetlands.

12. A habitat assessment of streams is needed to determine which streams do support fish or are capable of supporting fish.

13. Those stream stations that do support fish will be sampled to obtain fish tissue quality data.

14. A habitat assessment of ponds, wetlands, and non-fish-bearing streams is needed to determine utilization by wildlife, livestock, and birds.

15. Riparian zone vegetation quality will be characterized to determine the extent of contamination in this habitat along streams, ponds, seeps, springs, and other wetlands.

16. P_4 Production will undertake a study to evaluate a suitable seed mixture that provides desirable traits for reclamation—erosion control, cover, and future grazing potential.

17. P_4 Production will incorporate asters into their weed control program, identify the locations of their occurrences on Enoch Valley Mine, and begin to control them.

18. A veterinary toxicology panel will be formed to review existing information on livestock exposure to seleniferous vegetation on waste rock dumps. The panel, which will hopefully be chaired by Dr. Patricia Talcott, will help determine whether it is safe to allow different species of livestock to graze the dumps, any mitigating measures that need to be taken for grazing to occur, and to identify further data needs to allow these determinations to be made.

19. Existing mine maps will be compiled to be used in the EE/CA process to evaluate certain alternatives. Furthermore, a circum-dump reconnaissance of waste rock dumps at each mine site will be performed to identify and map mass wasting, potential mass wasting and control areas along dump boundaries.

20. Characterize the change in quality of soil from waste rock dumps onto adjacent rangeland in areas susceptible to mass wasting.

21. Characterize the change in quality of vegetation from waste rock dumps onto adjacent rangeland in areas susceptible to mass wasting.

22. The final stages of Enoch Valley Mine entailed the placement of a non-seleniferous cap to isolate seleniferous shales from the root zone. Performance monitoring of this cap will be conducted.

The SI tasks in Table 3-3 and described below in Section 4.0 of this PjtWP were derived with the above objectives in mind, as were the sampling locations and frequencies described in detail within Section 4.0 of the mine-specific PjtFSP.

TABLE 3-3
WORK BREAKDOWN STRUCTURE— ENOCH VALLEY MINE
TASKS, SUBTASKS, AND ACTIVITIES

TASK	SUBTASK	ACTIVITY
Task 1—Surface Water and Sediment Investigation	Subtask 1a—Investigation of historical irrigation practices	
	Subtask 1b—Surface water and sediment sampling	Activity 1b-1—impacted riparian zones
		Activity 1b-2—fish tissue quality investigation
Task 2—Air Investigation	Subtask 2a—Data compilation	
Task 3—Geology and Groundwater Investigation	Subtask 3a—Phase 1 Investigation	Activity 3a-1—review available hydrogeologic information
		Activity 3a-2—well inventory
		Activity 3a-3—spring and seep survey
		Activity 3a-4—spring and dump seep flow characterization
		Activity 3a-5—sampling existing mine and domestic wells, springs and seeps
		Activity 3a-6—revise conceptual hydrogeologic site model
	Subtask 3b—Phase II Investigation	Activity 3b-1—well installations, as necessary based on data gaps in conceptual model or to confirm components of the model
		Activity 3b-2—sampling of new and existing wells, springs, seeps, as appropriate
Task 4—Soil Investigation	Subtask 4a—Water balance investigation	
	Subtask 4b—Characterization of extent of riparian zone soil contamination at streams, ponds, seeps, springs, and wetlands	
	Subtask 4c—Characterization of waste rock dump extent of soil contamination	
Task 5—Aquatic Ecological Investigation	Subtask 5a—Stream habitat assessment	
	Subtask 5b—Fish tissue quality investigation	
Task 6—Terrestrial Ecological Investigation	Subtask 6a—Habitat assessment of ponds, wetlands, and non-fish-bearing streams	
	Subtask 6b—Characterization of extent of riparian zone vegetation contamination at streams, ponds, seeps, springs, and wetlands	
	Subtask 6c— Evaluate potential replacements for alfalfa in reclamation seed mix	
	Subtask 6d— Identification and location of known selenium absorber species	
	Subtask 6e— Veterinary toxicology panel on livestock utilization of reclaimed land	
	Subtask 6f—Characterization of waste rock dump extent of vegetation contamination	
	Subtask 6g— Performance monitoring of non-seleniferous cap	
Task 7—Facilities Investigation		
Task 8—Data Validation	Subtask 8a—Surface water	
	Subtask 8b—Sediment	
	Subtask 8c—Groundwater	
	Subtask 8d—Soil	
	Subtask 8e—Fish	
	Subtask 8f—Vegetation	
Task 9—Data Evaluation	Subtask 9a—Surface water	
	Subtask 9b—Sediment	
	Subtask 9c—Groundwater	
	Subtask 9d—Soil	
	Subtask 9e—Fish	
	Subtask 9f—Vegetation	
Task 16*—Reporting		
Task 17—Project and Program Management		
Task 18—Meetings		

*Tasks 10–15 are reserved for the EE/CA.

Appendix P
Quality Assurance Plan - A Functional Upper Bound of Background

P_4 Production, LLC

A Joint Venture of

MONSANTO imagine™

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SOUTHEAST IDAHO MINE-SPECIFIC SELENIUM PROGRAM

Comprehensive Site Investigation

Program Quality Assurance Plan—Final

April 2004

Prepared by

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NOTE:

Appendix G has been reproduced here. For the entire Quality Assurance Plan, please review the original document.

Appendix G
A Functional Upper Bound of Background

A Functional Upper Bound of Background

MWH Global Energy & Industry
Mining Group
Bellevue, WA, USA
September 3, 2003

Purpose

When investigating a contaminated site the background distribution of an analyte of interest must be characterized to determinate whether the analyte is a contaminant. If it is a site contaminant, knowledge of its background distribution may be used to help determine whether its release poses an unacceptable risk. If the contaminant does pose an unacceptable risk, knowledge of its background distribution may be used to help determine an appropriate cleanup goal. Thus, background data are critical, as is the protocol used to evaluate the data.

The average is often used, inappropriately, as a bright line to characterize background. If the background average is used, it should only be compared to the average for the contaminated site in question (e.g., with a t test); however, any average for the site as a whole may be misrepresentative. For example, if only a small portion of the site is contaminated, a large number of data from clean portions of the site may swamp a small number of contaminated data points and result in a comparison to background that fails to show contamination.

Use of the background average as a simple bright-line decision point to identify hot spots will, on the other hand, falsely identify far too many uncontaminated portions of a site as contaminated. In fact, if the background conditions were well described by a normal distribution (which is not usually the case), the use of the background average as a bright line would result in about half of background being misidentified as contaminated.

Given that an average, or any confidence bound on it (a confidence bound converges to the parameter in question given a large enough sample size), is an inappropriate bright line by which to characterize background, an alternative parameter is needed. The most appropriate is a high-end percentile of the background distribution.

Regulatory guidance most often identifies an appropriate high-end percentile to be the 95th percentile, or $p_{0.95}$. Because there is almost always substantial uncertainty in estimating $p_{0.95}$ (or any other parameter), a confidence bound is used. The resulting statistic can be denoted as $\hat{p}_{0.95;\,1-\alpha,n}$, where the hat indicates an estimate, α is the false-positive error rate, and n is the sample size. Convention sets α at 0.05, and the resulting $\hat{p}_{0.95;\,0.95,n}$ is frequently called the 95/95 upper tolerance bound, because it bounds 95% of the distribution with 95% confidence.

A problem with use of $\hat{p}_{0.95;\,0.95,n}$ is that, with small background sample sizes typically encountered in contaminated site investigations, it often generates unreasonably high values. It is not uncommon for $\hat{p}_{0.95;\,0.95,n}$ to exceed 1,000,000 ppm, a physical impossibility. The appropriate interpretation of such numbers is that there is a need for further background sampling. However, use of $\hat{p}_{0.95;\,0.95,n}$ is not always feasible given budget constraints typically placed on background investigations. To counter a perception of non-credibility of $\hat{p}_{0.95;\,0.95,n}$, some have used $\hat{p}_{0.90;\,0.90,n}$. However, this does not eliminate the problem of non-credible results when n is small and s, the sample standard deviation, is large. Furthermore, the use of $p_{0.90}$ as the parameter of interest is troubling to regulated parties as it implies that they are to be held accountable for approximately 10% of background, which can be an unacceptable amount at large sites. Finally, the use of an α of 0.10, twice the traditional value, smacks of statistic shopping (i.e., searching for a statistic that gives the desired results), thus causing a further erosion of credibility.

The purpose of this paper is to, within the context of an objective protocol, evaluate alternative high-end percentile statistics that avoid the problems inherent with $\hat{p}_{0.95;\,0.95,n}$, and recommend one for use as a bright line to characterize background.

Methods

Because lognormality is the best *a priori* assumption of distributional form for analytes in the environment, and, because environmental analyte concentration distributions have bounds, our null hypothesis of background distribution form is 4-parameter lognormal, $LN(\bar{x}_T, s_T, \hat{\lambda}, \hat{\upsilon})$, where:

- $\bar{x}_T$ is the sample mean of the 4-parameter ln-transforms, which are calculated—

$$x_{i,T} = \ln\left(\frac{x_i - \hat{\lambda}}{\hat{\upsilon} - x_i}\right), \qquad \text{Equation 1}$$

with the back-transformation being—

$$x = \frac{\hat{\upsilon}e^{x_T} + \hat{\lambda}}{1 + e^{x_T}}; \qquad \text{Equation 2}$$

- s_T is the sample standard deviation of the 4-parameter ln-transforms;
- $\hat{\lambda}$ is an estimate of the population lower bound; and,
- $\hat{\upsilon}$ is an estimate of the population upper bound.

The values of $\hat{\lambda}$ and $\hat{\upsilon}$ are generated by optimizing a 4-parameter lognormal fit plot of $x_{i,T}$ on z_i, the standard normal variate. The values of z_i are calculated using the Blom plotting position:

$$q_i = \frac{i - 0.375}{n + 0.25} \qquad \text{Equation 3}$$

where q_i is the quantile of the i^{th} ordered background datum (with background observations ordered 1 through n). Each q_i is then transformed to z_i by means of a standard normal distribution inverse function (e.g., Excel's NORMSINV). The fit plots are tested using a probability plot correlation coefficient test of normality.

Optimizing of the fit plot occurs by maximizing the correlation coefficient, $r_{x_{i,T}:z_i}$, by iterative calculation. The initial assumption for $\hat{\lambda}$ is 0, unless the data contain negative observations. Negative observations are almost sure to arise in uncensored data, due to measurement error, for background characterizations of trace elements, naturally occurring radionuclides, or widespread anthropogenic contaminants that are present in trace amounts. In these cases, the initial assumption for $\hat{\lambda}$ is the negative value just below (to a two-significant-digit resolution) the lowest observation. Because of mathematical constraint, $\hat{\lambda}$ may not exceed the lowest observation.

The initial assumption for $\hat{\upsilon}$ is pure substance (e.g., 1,000,000 ppm). A refinement would be to use a level of saturation or some global maximum observation. By physical constraint, $\hat{\upsilon}$ may not exceed the initial assumption, and may not be lower than the highest observation.

Another constraint we shall place upon the bounds, to be reasonable, is that they must, at a minimum, be an order of magnitude beyond their respective extreme observation. Mathematically:

$$\hat{\upsilon} \geq 10x_n \qquad \text{Equation 4}$$

and, if x_1 is positive:

$$\hat{\lambda} \leq \frac{x_1}{10} \qquad \text{Equation 5a}$$

or, if x_1 is negative:

$$\hat{\lambda} \leq 10x_1 . \qquad \text{Equation 5b}$$

These constraints avoid the arrogance of assuming that the extreme observations approach the bounds.

Once the optimized values of $\hat{\lambda}$ and $\hat{\upsilon}$ are generated, the observed range, $x_n - x_1$, is compared to the "range" defined by including each bound in turn, $\hat{\upsilon} - x_1$ and $x_n - \hat{\lambda}$, respectively. If the difference in a "range" for a given bound, relative to the observed range, is in excess of three orders of magnitude, then the bound associated with that "range" is deemed to be functionally equivalent to $-\infty$ or ∞, as appropriate, and is discarded. This results in one of four possible outcomes:

- If neither bound is discarded, the null hypothesis of 4-parameter lognormality is retained;
- If $\hat{\upsilon}$ is discarded and $\hat{\lambda}$ is retained, the null hypothesis is rejected in favor of an alternative hypothesis of 3-parameter lognormality;
- If $\hat{\lambda}$ is discarded and $\hat{\upsilon}$ is retained, the null hypothesis is rejected in favor of an alternative hypothesis of mirror-image 2-parameter lognormality (i.e., a lognormal distribution skewed to the left instead of the right); and,

- If both $\hat{\lambda}$ and $\hat{\upsilon}$ are discarded, the null hypothesis is rejected in favor of an alternative hypothesis of normality.

Goodness of fit is measured with the probability plot correlation coefficient test of normality ($\alpha = 0.05$) on the 4-parameter ln-transformed, 3-parameter ln-transformed, mirror-image 2-parameter ln-transformed, or untransformed concentration data, as appropriate. The equations for a 4-parameter ln-transformation and its back-transformation are provided in Equations 1 and 2 above.

The equation for a 3-parameter ln-transform is:

$$x_{i,T} = \ln\left(x_i - \hat{\lambda}\right). \qquad \text{Equation 6}$$

The back-transformation is:

$$x = e^{x_T} + \hat{\lambda}. \qquad \text{Equation 7}$$

The equation for a mirror-image 2-parameter ln-transformation and back-transformation are, respectively:

$$x_{i,T} = \ln\left(\hat{\upsilon} - x_i\right) \qquad \text{Equation 8}$$

and:

$$x = \upsilon - e^{x_T} \qquad \text{Equation 9}$$

If none of these distributions is found to fit, an alternative transformation is sought or the data are inspected to see if they include multiple distributions that need to be separated. The latter may, for example, be due to the presence of more than one distinct background stratum, or to a contaminated area being misclassified as background.

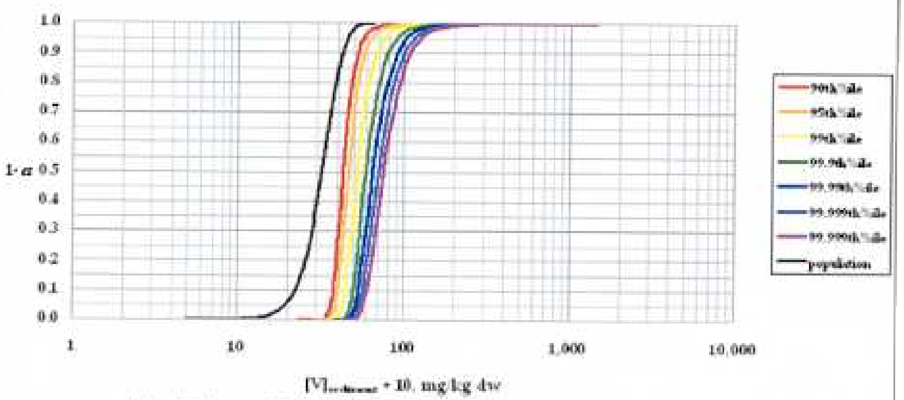
Results

Using the above protocol we selected four trace element background data sets, one fitting each of the four distributional forms, from a selenium release program being conducted in the phosphate mining district of Southeast Idaho (Monsanto, Spring 2002, n = 6):

- 4-parameter lognormally distributed V in sediment;
- 3-parameter lognormally distributed Se in surface water;
- mirror-image 2-parameter lognormally distributed Zn in sediment; and,
- normally distributed Cd in surface water.

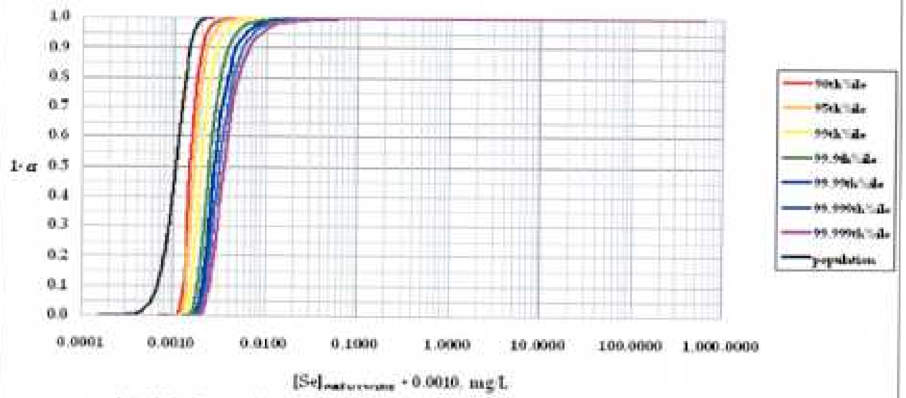
After determining the distribution for each of the above, estimates were calculated of various high-end percentiles—the 90^{th}, 95^{th}, 99^{th}, 99.9^{th}, 99.99^{th}, 99.999^{th}, and 99.9999^{th}—of each distribution for a wide array of confidence levels—from 0.0001% to 99.9999%. These results were plotted, along with the distribution itself, to allow for direct visual comparison of the traditional bright line, $\hat{p}_{0.95;\,0.95,n}$, against alternatives, various $\hat{p}_{p;1-\alpha,n}$. These cumulative plots are displayed in Figures 1 through 4 below. In each of the figures the left-most line, which is black, represents the best estimate of the background distribution, and the remaining lines represent various high-end percentiles.

Figure 1. Uncertainties in High-End Percentiles of 4-Parameter Lognormally Distributed Background $[V]_{sediment}$ LN(-2.23, 0.04, -180, 1,900) mg/kg dw, n = 6.



data shifted upward by 10 to eliminate negative values for log-scale plotting

Figure 2. Uncertainties in High-End Percentiles of 3-Parameter Lognormally Distributed Background $[Se]_{surface\ water}$ LN(-6.19, 0.15, -0.0020) mg/L, n = 6.



data shifted upward by 0.0010 to eliminate negative values for log-scale plotting

Figure 3. Uncertainties in High-End Percentiles of Mirror-Image Lognormally Distributed Background $[Zn]_{sediment}$: 1,200-LN(7.03, 0.03) mg/kg dw, n = 6.

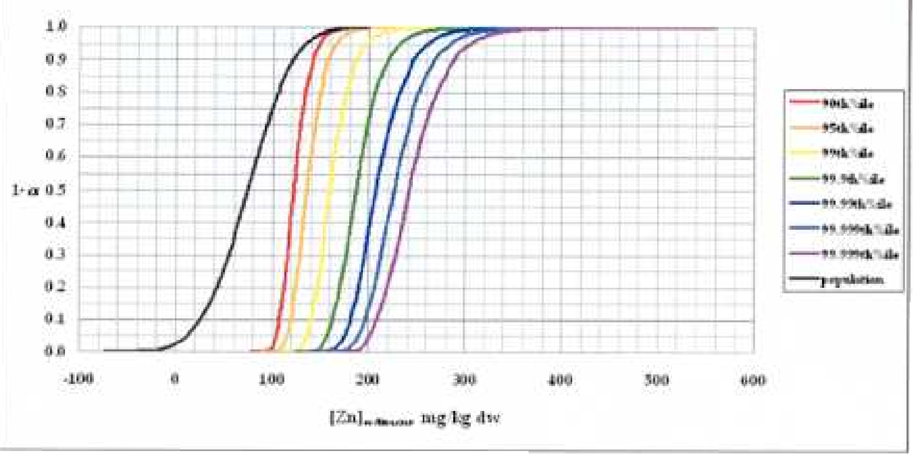
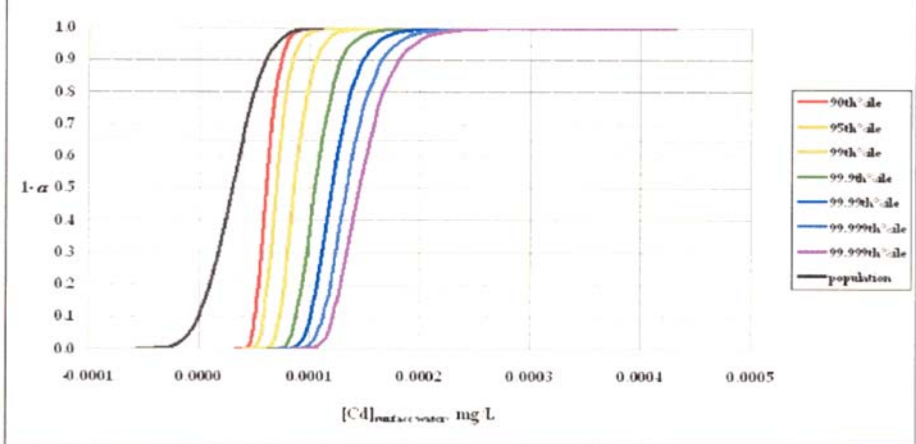


Figure 4. Uncertainties in High-End Percentiles of Normally Distributed Background $[Cd]_{surface\ water}$: N(0.000030, 0.000024) mg/L, n = 6.



Discussion

The initial use of an upper bound on the background distribution, through the null hypothesis of 4-parameter lognormality, virtually eliminates the $\hat{p}_{0.95;\,0.95,n}$'s problem of potential unrealism with small values of n. Simplifying the distributional form by eliminating bounds only when they are shown to be sufficiently distant from the observed data ensures that this problem won't arise (as long as outrageously extreme percentiles are of no interest). Thus, the protocol used for determining distribution form, while more complex than state of the practice, is logical and helps to produce a desired effect.

The figures above graphically demonstrate that estimates of high-end percentiles, just like any statistic, have uncertainty in both directions. Generally this uncertainty is much greater on the high end of the estimates of these percentiles, as is evidenced by decreased slopes of the plots at the higher confidence levels. One way, therefore, to reduce the degree of uncertainty would be to work with the lower end of these percentiles, in other words, to use a lower confidence bound on the percentile rather than an upper confidence bound.

For a lower confidence bound to be reasonable, the high-end percentile of interest must be more reasonable than the 95th percentile. It was mentioned earlier that a high-end percentile of 90% puts the regulated party in a position of having to assume responsibility for 10% of Mother Nature, but 5% is not much of a difference when the responsibility is as great as it is with contaminated sites.

We are proposing, after discussion with IDEQ, the use of the 99.9th percentile as the parameter of interest. Use of 99.9% as a target is far more palatable from all perspectives. One can argue that the assumption of responsibility for 0.1% of Mother Nature is a *de minimus* penalty to pay for all but the largest of sites.

As to the choice of which lower bound to use, application of tradition dictates use of an α of 0.05, i.e., a confidence level, $1-\alpha$, of 95%. However, since we're working on the low end of the statistic, the confidence level of interest in Figures 1 through 4 is 0.05. Thus, we are proposing that the functional upper bound of background be $\hat{p}_{0.999;\,0.05,n}$.

An examination of the figures shows that in all cases the $\hat{p}_{0.999;\,0.05,n}$ generates credible estimates of a functional upper bound, regardless of distribution form. Values of interest are presented in Table 1.

Table 1. Statistics of Interest.							
Analyte	Distribution	n	$\hat{p}_{0.9;\,0.9,n}$	$\hat{p}_{0.95;\,0.95,n}$	$\hat{p}_{0.999;\,0.05,n}$	$\hat{p}_{0.999}$	$\frac{\hat{p}_{0.999}}{p_{0.999;0.05,n}}$
$[V]_{sed}$ mg/kg dw	4-parameter lognormal	6	42	53	38	49	1.3
$[Se]_{sw}$ mg/L	3-parameter lognormal	6	0.0010	0.0016	0.00077	0.0014	1.8
$[Zn]_{sed}$ mg/kg dw	mirror-image 2-parameter lognormal	6	160	200	140	190	1.4
$[Cd]_{sw}$ mg/L	normal	6	0.000089	0.00012	0.000076	0.00011	1.4

Table 1 shows that $\hat{p}_{0.999;\,0.05,n}$ is, in all four examples, lower than the traditionally used $\hat{p}_{0.95;\,0.95,n}$. The $\hat{p}_{0.999;\,0.05,n}$ is even lower than $\hat{p}_{0.9;\,0.9,n}$ in each case. Thus, it appears, even with examples using sample sizes that are a bit larger than what is often encountered, that the $\hat{p}_{0.999;\,0.05,n}$ performs well from a regulator's perspective.

From the perspective of a regulated party, the ratio $\hat{p}_{0.999}/\hat{p}_{0.999;\,0.05,n}$ (where $\hat{p}_{0.999}$ is the best estimate of the 99.9th percentile) gives a measure of the value of information additional background samples might provide—the higher this ratio, the more room for improvement. These numbers indicate that additional sampling of V or Zn in sediment or Cd in surface water would likely not be wise investments; however, additional sampling of Se in surface water may prove to be worth while.

Conclusion

In summary, $\hat{p}_{0.999;\,0.05,n}$ generates bright-line background values that are credible and that avoid the pitfalls associated with use of the traditional $\hat{p}_{0.95;\,0.95,n}$. The use of $p_{0.999}$ as a target parameter is more palatable to those who are regulated, yet reasonable to those who are regulating. The use of 95% confidence—to bound the uncertainty on the lower side—retains tradition and thus enhances credibility. Finally, use of a lower bound on $\hat{p}_{0.999}$ provides regulated parties with a potential business incentive to design better background investigations. The reduction of uncertainty that will result will prove to be a benefit to all.

Using a lower confidence bound requires a caution. Multiple comparisons, each performed at an α of 0.05, rapidly increase the experiment-wise type I error rate, α_{exp}. Thus, care should be taken—when multiple contaminants, media, monitoring periods, or other circumstances lead to multiple comparisons—to control α_{exp}.

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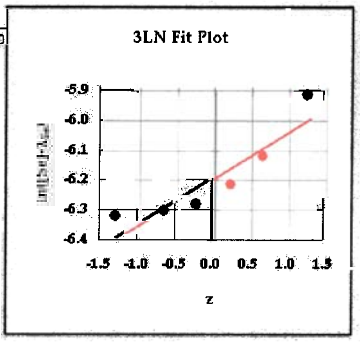
Attachment A
Raw Data and Fit Plots

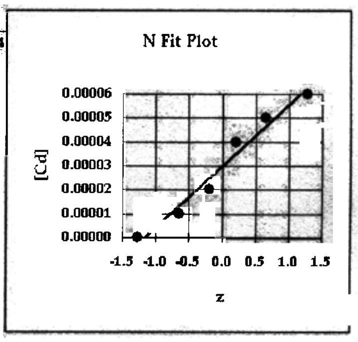
Background Data				
Station ID	Surface Water, mg/L		Sediment, mg/kg dw	
	[Se]	[Cd]	[V]	[Zn]
MRV017	0.00020	0.000040	11	21
MST235	0	0.000010	18	37
MST049	-0.00017	0.000020	30	95
MST093	0.00070	0.000060	32	120
MST101	-0.00020	0	21	90
MST237	-0.00013	0.000050	21	80

Concentrations	Ranks	Quantiles	Standard Normal Variates	Lower Bound	Upper Bound	4LN Transformations	Correlation Coefficient	Decision Criterion	Reasonableness of Bounds	Simplified Transformations	Correlation Coefficient	Fit Plots

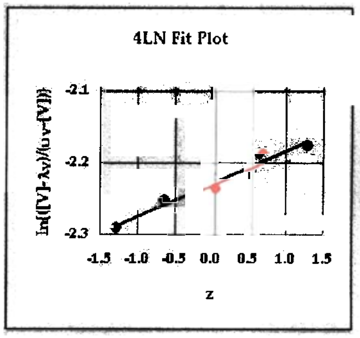
$[Se]_{sw}$	i	q	z	λ	υ	$\ln\{([Se]-\lambda_{Se})/(\upsilon_{Se}-[Se])\}$	r_{xz}	$\lvert r_{0.050,6}\rvert$	$\log[(x_n-\lambda_{Se})/(x_n-x_1)]$	$\ln([Se]-\lambda_{Se})$	$r_{3LN[Se]z}$
-0.00020	1	0.10	-1.28	-0.0020	1,000,000	-20.14	**0.920**	0.888	0.5	-6.32	0.920
-0.00017	2	0.26	-0.64			-20.12	Retain H_0: data are 4LN.		$\log[(\upsilon_{Se}-x_1)/(x_n-x_1)]$	-6.30	
-0.00013	3	0.42	-0.20			-20.10			9.0	-6.28	
0	4	0.58	0.20			-20.03			Simplify H_0 to: data	-6.21	
0.00020	5	0.74	0.64			-19.93			are 3LN.	-6.12	
0.00070	6	0.90	1.28			-19.73				-5.91	



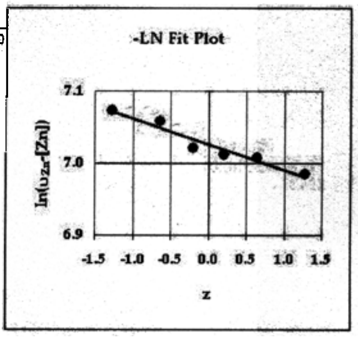
$[Cd]_{sw}$	i	q	z	λ	υ	$\ln\{([Cd]-\lambda_{Cd})/(\upsilon_{Cd}-[Cd])\}$	r_{xz}	$\lvert r_{0.050,6}\rvert$	$\log[(x_n-\lambda_{Cd})/(x_n-x_1)]$	$[Cd]$	$r_{[Cd]z}$
0	1	0.10	-1.28	-9.0	1,000,000	-11.62	**0.984**	0.888	5.2	0	0.984
0.000010	2	0.26	-0.64			-11.62	Retain H_0: data are 4LN.		$\log[(\upsilon_{Cd}-x_1)/(x_n-x_1)]$	0.000010	
0.000020	3	0.42	-0.20			-11.62			10.2	0.000020	
0.000040	4	0.58	0.20			-11.62			Simplify H_0 to: data	0.000040	
0.000050	5	0.74	0.64			-11.62			are N.	0.000050	
0.000060	6	0.90	1.28			-11.62				0.000060	



$[V]_{sed}$	i	q	z	λ	υ	$\ln\{([V]-\lambda_V)/(\upsilon_V-[V])\}$	r_{xz}	$\lvert r_{0.050,6}\rvert$	$\log[(x_n-\lambda_V)/(x_n-x_1)]$
11	1	0.10	-1.28	-180	1,900	-2.29	**0.981**	0.888	1.0
18	2	0.26	-0.64			-2.25	Retain H_0: data are 4LN.		$\log[(\upsilon_V-x_1)/(x_n-x_1)]$
21	3.5	0.50	0.00			-2.24			2.0
21	3.5	0.50	0.00			-2.24			Do not simplify H_0.
30	5	0.74	0.64			-2.19			
32	6	0.90	1.28			-2.18			



$[Zn]_{sed}$	i	q	z	λ	υ	$\ln\{([Zn]-\lambda_{Zn})/(\upsilon_{Zn}-[Zn])\}$	r_{xz}	$\lvert r_{0.050,6}\rvert$	$\log[(x_n-\lambda_{Zn})/(x_n-x_1)]$	$\ln(\upsilon_{Zn}-[Zn])$	$r_{-LN[Zn]z}$
21	1	0.10	-1.28	-1,000,000	1,200	6.74	**0.970**	0.888	4.0	7.07	-0.970
37	2	0.26	-0.64			6.76	Retain H_0: data are 4LN.		$\log[(\upsilon_{Zn}-x_1)/(x_n-x_1)]$	7.06	
80	3	0.42	-0.20			6.79			1.1	7.02	
90	4	0.58	0.20			6.80			Simplify H_0 to: data	7.01	
95	5	0.74	0.64			6.81			are -LN.	7.01	
120	6	0.90	1.28			6.83				6.98	



Appendix Q
Chromium Speciation Technical Memorandum

M E M O R A N D U M

MWH
2353 130th Avenue N.E., Suite 200
Bellevue, Washington 98005
Phone: (425) 602-4000
Fax: (425) 867-1970

To: Rick Clegg, IDEQ
Cc: Bob Geddes, P_4 Production, LLC
From: Mark Rettmann, MWH
Bill Wright, MWH

Date: June 1, 2005

Reference: P_4 Production Southeast Idaho Mine-Specific Selenium Program

Subject: Chromium Speciation Study in Pond Sediment, Stream Sediment, Stream Riparian Soil, and Waste Rock Dump Soil

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Introduction

This technical memorandum documents the results and findings of the chromium speciation study conducted as part of the P_4 Production Southeast Idaho Mine-Specific Selenium Program. This study supports the site investigations (SIs) at P4 Production's Enoch Valley, Henry, and Ballard mines. A Chromium Speciation Sampling Memo, included as Attachment A, was prepared on July 6, 2004, to serve as a work plan/field sampling plan. It documents sampling and laboratory analysis procedures, sampling stations, proposed evaluation, and background regarding the need for this chromium speciation study. The memo was prepared with technical input from the Idaho Department of Environmental Quality and was approved by IDEQ prior to sampling in July 2004.

This study was conducted to determine the local or mine-specific ratio of hexavalent chromium (Cr[VI]) to total chromium in pond and stream sediments, stream riparian soil, and waste rock dump soil. The IDEQ would not allow P4 Production to drop chromium from the analyte list for the SIs based on the interim surface water and sediment data collected in 2002. In IDEQ's comments on P4 Production's Draft SI and EE/CA Work Plans, IDEQ recommeded that site-specific speciation studies be conducted by P4 Production. IDEQ's comment and P4 Production's response as found in the document entitled "Responses to Agency Comments on Draft SI and EE/CA Work Plans" is included below.

> "24. **IDEQ Comment:** Section 3.1.1, Page 3-7, 1st-3rd Para: The Statement of Work contained in Monsanto's executed Administrative Order on Consent specifies the contaminants of concern for the Site Investigations. Monsanto may add other constituents of interest, if so desired, but they are not at liberty to drop or replace the specified analytes, particularly for optimizing laboratory costs. The designate COC list consists of Se, Cd, Cr, Ni V, and Zn for all media except vegetation and regulated surface water, which may exclude Cr, Ni and V. If Monsanto wants to pursue elimination of Chromium from the soil and sediment COC list based on their understanding of the current screening assumptions, they should propose site-specific speciation studies that clearly document the current assumptions used by USEPA and NOAA in establishing their Cr threshold values.

Cr should not be dropped from the COC list until the results of the study are reviewed and approved by the Agencies.

Response: *Accepted with clarification. It appears simpler and more accurate to state that the agencies are willing to drop chromium, nickel, and vanadium in all media except groundwater, soil, and sediment. P_4 Production may specify that these target elements are retained for these three media but may, upon IDEQ approval, be dropped following receipt, review, and approval of appropriate studies or arguments. Specifically, P_4 Production is planning a speciation study for chromium in sediment and soil to document the proportion of the hexavalent species relative to the 14% assumed by USEPA in establishing risk-based benchmarks. P_4 Production will document the plans for this study by means of program memorandum and will be asking for agency input on sampling locations (P_4 Production is looking at biased sampling of areas known or suspected of being chromiferous). P_4 Production is considering risk-based arguments for the deletion of nickel and vanadium in soil. In summary, the three elements mentioned in this comment will be added to the contaminant of potential concern list for groundwater, sediment, and soil pending approval to do otherwise from the agencies."*

Sampling Summary

Chromium speciation sampling was conducted on July 15, 16, and 17 of 2004. A total of fourteen samples were analyzed for total chromium by method 3050/6010 and hexavalent chromium by method 3060/7196. The fourteen samples were collected from the various media at the following locations:

- Three sediment samples collected from ponds (MSP019, MSP055, and MSP059);
- Three sediment samples collected from streams (MST130, MST089, and MST067);
- Three riparian soils collected near streams (MST130, MST089, and MST067);
- Three waste rock soil samples collected from Spring 2001 waste rock dump locations (MWD091-2, MWD086-0, MWD080-6); and,
- Two field QA samples (equipment blank and deionized source water blank).

The three Spring 2001 waste rock dump station locations were located using the Spring 2001 station GPS coordinates. Black shales at the three waste rock dump stations were sampled since the sampling in Spring 2001 was biased towards them and we hypothesized that this form of waste rock would be likely to have the highest mineral content. (Pond sediments, which are primarily run-of-mine waste rock, would be expected to give a more averaged result.) Table 1 below presents the July 2004 station coordinates for this activity.

Table 1

GPS Station Coordinates for Chromium Speciation Sampling			
Station Name	Station	GPS Coordinates[a]	
		Latitude	Longitude
Enoch Valley Mine Bat Cave Pond	MSP019	42 52 23 N	111 24 05 W
Henry Mine South Pit Pond	MSP055	42 51 35 N	111 27 06 W
Ballard Mine Pit #4 Stock Pond	MSP059	42 49 12 N	111 28 53 W
Ballard Creek, headwaters	MST067	42 49 24 N	111 29 36 W
Wooley Valley Creek, below North Fork Wooley Valley Creek	MST089	42 49 29 N	111 26 19 W
Angus Creek, below Angus Creek Reservoir	MST130	42 49 38 N	111 23 58 W
Ballard Mine Pit #1 Overburden Dump #1	MWD080	42 50 00 N	111 29 40 W
Henry Mine Pit #1 Overburden Dump	MWD086	42 52 41 N	111 28 01 W
Enoch Valley Mine South Dump	MWD091	42 51 57 N	111 23 39 W

Notes:
[a] NAD27 datum, reported as (degrees, minutes, seconds)

Sample Results

Table 2 below presents the results of the chromium speciation sampling (total and hexavalent chromium).

Table 2

Total and Hexavalent Chromium in Sediment, Riparian Soil, and Waste Rock Soil (mg/kg-dw)[a]						
Station Name	Station	Matrix, Feature	Total Chromium (EDL, 1.5)	Flag	Hexavalent Chromium (EDL, 0.20)	Flag
Enoch Valley Mine Bat Cave Pond	MSP019	Sediment, Pond	450		-8.1	0.20 UJ
Henry Mine South Pit Pond	MSP055	Sediment, Pond	940		-4.1	0.20 UJ
Ballard Mine Pit #4 Stock Pond	MSP059	Sediment, Pond	870		-14	0.20 UJ
Ballard Creek, headwaters	MST067	Sediment, Stream	320		-35	0.20 UJ
Wooley Valley Creek, below North Fork Wooley Valley Creek	MST089	Sediment, Stream	110		-15	0.20 UJ
Angus Creek, below Angus Creek Reservoir	MST130	Sediment, Stream	100		-9.2	0.20 UJ
Ballard Creek, headwaters	MST067	Riparian Soil, Stream	120		-38	0.20 UJ
Wooley Valley Creek, below North Fork Wooley Valley Creek	MST089	Riparian Soil, Stream	48		-38	0.20 UJ
Angus Creek, below Angus Creek Reservoir	MST130	Riparian Soil, Stream	95		-9.3	0.20 UJ
Ballard Mine Pit #1 Overburden Dump #1	MWD080	Waste Rock Soil, WRD	900		7.3	J
Henry Mine Pit #1 Overburden Dump	MWD086	Waste Rock Soil, WRD	990		-6.3	0.20 UJ
Enoch Valley Mine South Dump	MWD091	Waste Rock Soil, WRD	1100		17	J
Total and Hexavalent Chromium in Quality Assurance Samples (mg/L)						
Angus Creek, below Angus Creek Reservoir	MST130	Water, QA Blank	0.00025	NA	-0.73	NA
Angus Creek, below Angus Creek Reservoir	MST130	Water, QA EQ Blank	0.0012	NA	-0.79	NA

Notes:
[a] All samples were analyzed at the University of Idaho - Analytical Sciences Laboratory, Holm Research Center
WRD - Waste Rock Dump

Flag refers to the USEPA data qualifier (flag) assigned to the data resulting from the data validation procedure. More than one flag may be assigned during the data validation process.

Data qualifier definitions are:

(U) - The material was analyzed for, but was not detected above the level of the associated value. The associated value is 5 X the highest blank concentration, or the sample detection limit.
(J) - The associated value is an estimated quantity.
(R) - The data are unusable.
(UJ) - The material was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.
NA - Not Applicable

Data Evaluation

All hexavalent chromium results were not detected above the laboratory's estimated detection limit of 0.20 mg/kg for all the samples except two of the three waste rock soils. All sediment-pond, sediment-stream, and riparian soil sample were not detected.

The site-specific proportions of Cr(III) and Cr(VI) were determined by medium (i.e., pond sediment, stream sediment, stream riparian soil, and surficial waste rock soil). Riparian soil applies only to stream riparian soils and pond riparian zones are regarded as run-of-mine surficial waste rock, while the surficial waste rock category is specific to black shales (i.e., relatively unweathered, and supposedly highly mineralized, waste shales). For each of the four media, the observed ratios were fit to a 4-parameter lognormal distribution and the 95th percentile of that distribution was calculated. The ratios were assumed to be between -1 and 1. (Because data were not censored, negative results have to be accommodated; these provide a measure of the overall error of the analytical method below the estimated detection limit).

The site-specific total chromium PRGs by medium were then calclulated using the site-specific proportions of Cr(III) and Cr(VI). Because Cr(VI) is far more toxic than Cr(III), the site-specific PRG, in the presence of any Cr(VI), is simply inversely proportional to the fraction of total Cr that is hexavalent (i.e., the lower the proportion of Cr(VI), the higher the PRG). If no Cr(VI) is present, the total Cr PRG obviously defaults to the Cr(III) PRG. The site-specific proportions of Cr(III) to Cr(VI) by medium and the site-specific total chromium PRGs are provided in Table 3 below.

Table 3

Site-specific Adjustments of Total Cr PRG										
Analyte	USEPA-9 PRG, mg/kg dw	USEPA-9-assumed Proportions	Site-specific Proportions* by Medium				Site-specific PRG by Medium, mg/kg dw			
			pond sediment[1]	stream sediment[2]	riparian soil[3,3a]	surficial waste rock[4]	pond sediment	stream sediment	riparian soil	surficial waste rock
total Cr	450						2,800	100,000	100,000	3,400
Cr(III)	100,000	0.86	0.98	1.0	1.0	0.98				
Cr(VI)	64	0.14	0.023	-0.082	-0.067	0.019				

* Upper 95th percentile of the proportion of Cr(VI).

[1] Proportion of Cr(VI) distributed 4-parameter lognormally with a lower bound of -0.019 and an upper bound of 1.0.

[2] Proportion of Cr(VI) distributed 4-parameter lognormally with a lower bound of -0.60 and an upper bound of -0.065.

[3] Proportion of Cr(VI) distributed 4-parameter lognormally with a lower bound of -1.0 and an upper bound of -0.062.

[3a] Applies only to stream riparian zones; pond riparian zones are regarded as run-of-mine surficial waste rock.

[4] Proportion of Cr(VI) distributed 4-parameter lognormally with a lower bound of -1.0 and an upper bound of 0.023.

Conclusions

Table 3 above summarizes the mine-specific total chromium PRG by medium to be used for the P4 Production Southeast Idaho Mine-Specific Selenium Program.

The hypothesis stated in the Chromium Speciation Sampling Memo, "We believe the fraction of Cr(VI) is closer to 0% than the 14% assumed by EPA Region 9", has been accepted as the result of this mine-specific chromium speciation study. The percentage of hexavent chromium is documented herein to be well less than 3% (at the 95th percentile of the distribution) in all four media.

The mine-specific total chromium PRG was compared to the Interim Surface Water and Sediment Investigation results (sediment and surface water) and the 2004 Site Investigation results (sediment, surface water, and riparian soil). No results exceed the mine-specific PRGs.

Based on the mine-specific percentages of hexavalent chromium, and the fact that no results exceed the mine-specific total chromium PRGs, P4 Production recommends deleting chromium from the list of contaminants of potential concern for all media.

ATTACHMENT A

MEMORANDUM

MWH
2353 130th Avenue N.E., Suite 200
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Fax: (425) 867-1970

To: Rick Clegg, IDEQ
cc: Bob Geddes, P_4 Production, LLC
From: Bill Wright, MWH

Date: July 6, 2004

Reference: P_4 Production Southeast Idaho Mine-Specific Selenium Program (1010076.011601)

Subject: Chromium Speciation Sampling in Sediment, Riparian Soil, and Waste Rock Dump Soil

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Introduction

The purpose of this memorandum is to document the stations and media to be sampled for chromium speciation in 2004 as part of the P_4 Production Southeast Idaho Mine-Specific Selenium Program. This memorandum has been prepared with input from IDEQ. This activity supports the site investigations at P_4 Production's Enoch Valley, Henry, and Ballard mines. This activity, chromium speciation, is being conducted to determine the local or mine-specific ratio of hexavalent chromium (Cr[VI]) to total chromium in sediment, riparian soil, and waste rock dump soil.

Background

The reason determining the ratio of Cr(VI) is important is because the preliminary risk-based benchmark being used by the regulatory agency for chromium is the Region 9 Preliminary Remedial Goal (PRG) for total chromium. This preliminary benchmark assumes, unrealistically, that one-seventh (approximately 14%) of the chromium is present in the far more toxic hexavalent state. Trivalent chromium, the typical form found in the environment, is virtually non-toxic; in fact, it is a mineral widely used in high doses as a nutritional supplement. Trivalent chromium occurs naturally in rocks, soil, plants, animals, and volcanic emissions. This form is believed by many to play a nutritional or pharmaceutical role in the body, but its mechanism of action is unknown.

Hexavalent chromium is produced industrially when trivalent chromium (Cr[III]) is heated in the presence of mineral bases and atmospheric oxygen (for instance, during metal finishing processes). It is this form of chromium that has proven to be of the greatest occupational and environmental health concern. Hexavalent chromium is unstable under environmental conditions and is encountered as a contaminant under conditions where large quantities of the hexavalent form is used in an industrial process or when trivalent chromium is converted to hexavalent chromium under industrial processes.

It is for the above reasons, and the fact that there are no industrial processes using chromium at the mines under consideration, that the PRG assumed ratio is unrealistic. We believe the fraction of Cr(VI) is closer to 0% than the 14% assumed by EPA Region 9. The purpose of this activity is to establish the actual mine-specific ratio of hexavalent chromium to total chromium in sediment, riparian soil, and waste rock dump soil. Chromium in other environmental media is not of concern.

Sediment

Historical total chromium results in sediment for stations relating to P_4 Production's mines were reveiwed. One pond station from each of the three mines (i.e., three total ponds stations) and three stream stations, with the highest total chromium concentrations during the May 2002 interim surface water and sediment sampling event, were chosen for chromium speciation sampling for sediment.

The three pond stations (i.e., one station from each mine) with the highest total chromium in sediment are as follows:

- MSP059 (Ballard Mine Pit #4 Stock Pond) at 700 mg/kg dw,
- MSP055 (Henry Mine South Pit Pond) at 610 mg/kg dw, and
- MSP019 (Enoch Valley Mine Bat Cave Pond) at 580 mg/kg dw.

The three stream stations with the highest total chromium in sediment are as follows:

- MST130 (Angus Creek, below Angus Creek Reservoir) at 78 mg/kg dw,
- MST089 (Wooley Valley Creek, below North Fork Wooley Valley Creek) at 76 mg/kg dw, and
- MST067 (Ballard Creek, headwaters) at 76 mg/kg dw.

Riparian Soil

No historical chromium data for riparian soil exists for the P_4 Production mines. Therefore, riparian soil sampling will occur at the three stream stations that exhibited the highest total chromium in sediment and are listed above. One randomly selected composite soil sample will be collected at each location.

Waste Rock Dump Soil

Historical chromium data from waste rock dump soil sampling in Spring 2001 was reviewed. Black-shales on waste rock dumps will be sampled since the sampling in Spring 2001 was biased towards them. One black-shale sample will be collected from a waste rock dump at each of the three P_4 Production mines (i.e., three waste rock dump soil samples will be collected). One waste rock dump location from each mine with the highest concentration of total chromium will be sampled.

The three Spring 2001 waste rock dump stations (i.e., one station from each mine) with the highest total chromium in black shale soils are as follows:

- MWD091-2 (Enoch Valley Mine South Dump) at 1,400 mg/kg dw,
- MWD086-0 (Henry Mine Pit #1 Overburden Dump) at 1,100 mg/kg dw, and
- MWD080-6 (Ballard Mine Pit #1 Overburden Dump #1) at 1,100 mg/kg dw.

The stream and pond sampling stations and the waste rock dump locations specified above can be found on Figure 2-1, “Program Sampling Locations,” of the SAP.

Sampling and Analysis Procedures

Sampling procedures for this activity will be in accordance with the P_4 Production Southeast Idaho Mine-Specific Selenium Program, sampling and analysis plan (SAP), project work plans (PjtWPs), and project field sampling plans (PjtFSPs) supporting the site investigations (published 2004). Specifically, sampling procedures are detailed in the program Quality Assurance Plan (PgmQAP) of the SAP and relevant standard operating procedures (SOPs). Sediment sampling procedures are detailed in Section 6.2.6 of the PgmQAP and SOP-NW-9.3, “Collection of Sediment Samples”, riparian soil sampling procedures are detailed in Section 6.4.1 of the PgmQAP and SOP-NW-7.2, “Collection of Soil Samples”, and waste rock dump soil sampling procedures will be consistent with the procedures followed for the Spring 2001Area-Wide Investigation waste rock dump soil (i.e., black shales) sampling and SOP-NW-7.2, “Collection of Soil Samples”. The procedure for the Spring 2001Area-Wide Investigation waste rock dump soil sampling included locating an area of exposed black-shales upon a waste rock dump, obtaining GPS coordinates, digging an approximately 1-ft deep hole and obtaining the sample by scraping the face of the hole. No sieving in the field was performed.

The pond and stream sediment samples, the riparian soil samples, and the waste rock dump soil (i.e., black shales) samples will be analyzed at the University of Idaho, Holm Research Center, for total chromium by ICP (EPA 3050/6010) with a method detection limit (MDL) of 0.38 mg/kg dw and hexavalent chromium by alkaline digest & colorimetric analysis (EPA 3060/7196) with a MDL of approximately 0.10 mg/kg dw.

Data Evaluation

The mean percent hexavalent chromium and confidence and tolerance bounds will be calculated by medium. The mine-specific ratio of hexavalent chromium to total chromium in sediment, riparian soil, and waste rock dump soil will be determined from these results. This activity assumes that the fraction of hexavalent chromium is variable but in a way that is not dependent on the total chromium concentrations. In other words, locations with high concentrations of total chromium are being targeted in anticipation of seeing very low amounts of hexavalent chromium.

The sample results, and findings from this activity (i.e., mine-specific chromium ratio) will be reported in the SI report. If the results are as predicted, P_4 Production may use them as a basis for deleting chromium from the list of contaminants of potential concern.

ATTACHMENT B

MEMORANDUM

MWH
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To: Doug Tanner, IDEQ
Cc: Bob Geddes, P_4 Production, LLC
From: Mark Rettmann, MWH
Bill Wright, MWH

Date: August 17, 2005

Reference: P4 Production Southeast Idaho Mine-Specific Selenium Program

Subject: P4 Production's Response to USEPA-10's Comments on *Chromium Speciation Study in Pond Sediment, Stream Sediment, Stream Riparian Soil, and Waste Rock Dump Soil*, M. Rettmann and B. Wright, MWH (Memorandum to R. Clegg, IDEQ) June 1, 2005.

Comments on the Cr speciation memorandum were provided by R. Clegg, IDEQ, via e-mail on July 11, 2005. The comments were contained in the following letter: D. Tomten, USEPA-10 (Letter to R. Clegg, IDEQ) June 28, 2005. The letter contains seven specific comments, which are reproduced below and accompanied by our response.

1. The limited data that has been collected appears to confirm that Cr(VI) comprises a small fraction of total Cr in soil and sediment at these sites. This may be useful in evaluating risks to human health as the project moves forward, such as risks to subsistence users, and risks in residential and industrial exposure settings.

In pond sediments, the average fraction of Cr(VI) was found to be –0.79% with a 95th percentile of 2.3%. In stream sediments, the average fraction of Cr(VI) was found to be –12% with a 95th percentile of –8.2%. In stream riparian soil, the average fraction of Cr(VI) was found to be –41% with a 95th percentile of –6.7%. In surficial waste rock, the average fraction of Cr(VI) was found to be 0.31% with a 95th percentile of 1.9%. All of these average and high-end estimates are far below the USEPA-assumed Cr(VI) fraction of 14%. Given that the assumed fraction of Cr(VI) drives the development of risk and remediation benchmarks for total Cr, the site-specific findings in P4 Production's Cr speciation memorandum are notable in demonstrating that an assumption of a ratio of Cr(VI) to total Cr of 1/7 is overly conservative. In fact, the memorandum demonstrates that a conservative assumption for the three historic mines is more like a ratio of $1/7^2$—a substantial difference.

2. The approach and rationale uses EPA Region 9 risk-based screening levels developed for protection of human health in an industrial exposure setting to support conclusions about ecological risk associated with soil and sediment. This is an inappropriate comparison. The Region 9 screening levels are not relevant benchmarks for riparian soils and sediment at these sites where the primary question of interest is related to ecological risk.

We concur that use of ecological benchmarks for ecological concerns is best when such benchmarks are available or can be readily developed.

3. To make a case that Cr should not be a COPC at this site, it would be more appropriate to compare concentrations found in the various media to more appropriate and relevant risk-based concentrations for those media. A useful benchmark for comparison is the sediment quality guidelines summarized in the paper by MacDonald and others, 2001, which I will forward to you separately. That paper gives two chromium guidelines, a threshold effect concentration (TEC) of 43.4 mg/kg, and a probable effect concentration (PEC) of 111 mg/kg. The important number in this context may be the PEC.

We assume that the reference to MacDonald et al. (2001) is meant to be a reference to D.D. MacDonald, C.G. Ingersoll, and T.A. Berger, 2000, *Development and Evaluation of Consesus-Based Sediment Quality Guidelines for Freshwater Ecosystems*, **Arch. Environ. Contam. Toxicol. 39**:20-31. Rounding their "consensus" effects concentrations to two significant digits, we have used the TEC of 43 mg/kg dw as an aquatic ecological sediment screening benchmark, and we concur with the recommendation to use the PEC of 110 mg/kg dw. A search of the P4 Production database for sediment Cr results shows few exceedances of the PEC, and all these are at ponds, a few dump seeps, and contaminated springs.

4. There is also a soil screening level for the protection of groundwater which is 38 mg/kg. While Cr was not found in surface water, groundwater was not been sampled during the site-wide investigation. Thus, one does not know if Cr poses a risk to groundwater.

No groundwater sample to date has had a total Cr concentration in excess of the MCL of 0.10 mg/L. While irrelevant, it is interesting to note that no groundwater sample has even exceeded the coldwater biota standard for Cr—unless one cares to assume that the fraction of Cr(VI) is 40% or more, a virtual thermodynamic impossibility given a natural source of Cr.

We do not believe that an aquatic sediment benchmark (see response to comment #4 above) should be applied to soil if a more appropriate alternative exists. Literature seems to indicate the concern about Cr contamination in soil is phytotoxicity. Given that no phytotoxicity has been observed in either riparian soils or the surficial soils of waste rock dumps, we do not believe Cr in soil poses any ecological risk at or below P4 Production's three historic mines.

5. MWH proposes the highly unusual practice of reporting "uncensored" data in this context and elsewhere in site characterization activities related to the site. This raises several questions that should be resolved on a case-by-case basis, depending on context. In general, we agree that use and evaluation of uncensored data may have value in some contexts, such as evaluating error or uncertainty at levels below the detection level. However, we would also caution against using or comparing uncensored data below the detection level (which is not a detect and which may be indistinguishable from instrument noise) with data that is reliably quantified at levels above the detection level (which is detected and is clearly distinguishable from noise). Several questions would need to be addressed prior to approving use of uncensored data:

- Does censoring really degrade the quality of the data, if the data is still available? Isn't all data censored to some extent when an analyst rounds or using significant figures?
- How will uncensored data be used? What decisions will be made using this data? Is data generated very near the capability of the method (and which carries high relative uncertainty) needed to answer questions of interest or to support program decisions? What are the tolerable levels of uncertainty/error and what are the relative contributions to error from the entire process (field sampling, subsampling, preparation, calibration, dilutions, instrument noise, etc.)?
- What procedures or criteria will be used to distinguish between a hit/detection and noise? If you can't tell if you have a hit, how can you use uncensored data to characterize environmental conditions.
- Was the instrument calibrated at the levels to which the error statements are being made? Is calibration verified at or below the MDL? Was a standard used (not a blank) to show the instrument capable of reliably responding at or below the MDL?

A censored dataset is one of lower quality than its corresponding uncensored version. Thus, we find the penchant for some portions of USEPA to needlessly censor data befuddling. We can only assume that these portions of the agency value the simplicity of using censored data more than the data quality lost in the process. Attachment 1 contains numerous quotes from various sources, including USEPA, lamenting data censorship.

The uncertainty of data below the statistically defined limit of detection is always high. Perhaps the biggest damage censorship does is to underrepresent such uncertainty. Comparisons of data—whether below the limit of detection, above the limit of detection, or a mixture of the two—are appropriate with the use of statistical methods. The limit of detection itself is a statistically estimated value.

Censoring always degrades data quality. We therefore do not allow our laboratories to censor our data. We do, however, provide the reporting limit should a data user insist on censoring it. Attachment 2 provides a comparison of an analysis of the data contained in the Cr speciation memorandum—censored vs. uncensored. The censored data always has a higher mean, but may have a higher or lower 95th percentile. When not dealing with a ratio as we are here, it is common for the 95th percentile of a censored dataset to be lower than its corresponding uncensored version. Thus, data-censored versions may commonly underestimate uncertainty. Underestimation of uncertainty results in overconfidence—a major source of poor decision making.

Rounding data is not equivalent to censoring it. A censored datum has a less-than (or, for failure-analysis data, for example, greater-than) sign in front of it. A rounded datum just displays fewer significant digits than those reported by the lab. Censoring results in a loss of information that can be meaningful. Rounding to only two significant digits results in no loss of meaningful information.

Uncensored data are used just like censored data. The only difference is that there is no need to fabricate surrogate data to (mis)represent the censored data in statistical analyses and, as such, the resulting analyses are of a higher quality. The appropriate question is not how much uncertainty results from not censoring; it is how much results from censoring. Because those portions of USEPA that advocate data censorship have never addressed this important question, we reject data censorship (but, we provide the means by which to censor if one is so inclined). If censorship is embraced, we recommend a probabilistic data analysis in which each censored value is represented by a probability distribution, rather than a single point estimate, such as half of the reporting limit.

In any dataset, the only way one can tell a difference 'between' is to quantify such difference relative to differences 'among.' This is a basic purpose of statistics.

The limit of detection is determined by 'calibrating' an instrument with blanks. It is not necessary to use an infinite number of known calibration solutions to derive a curve showing concentration as a function of instrument response. We acknowledge high uncertainty below the statistically defined limit of detection; however, we do not believe that high uncertainty is a justification for ignoring uncertainty and misrepresenting it through censoring. Furthermore, just because a measurement is highly uncertain doesn't mean that it has no value. Any calibration curve (indeed, any regression) will be highly uncertain at both ends.

6. The SAP indicates that the MDL for Cr(VI) is .10 mg/kg. However, Table 2 indicates a detection limit of .20 mg/kg. Some additional information explaining this discrepancy should be provided.

The lab had not been routinely running Cr(VI) analyses; thus, the MDL reported in the sampling and analysis plan was estimated by them to be 0.10 mg/kg dw. After the analyses were conducted, the lab found that the MDL was 0.20 mg/kg dw, the value reported in the Cr speciation memorandum. The lab—the University of Idaho Analytical Sciences Laboratory—made a good estimate for planning purposes, and the resulting MDL indicates more than adequate analytical quality.

7. Samples MWD080 and 091 are quantitated well above the EDL of 0.20 but are flagged with a J qualifier. Why was this data qualified?

A matrix spike has a 71% recovery—outside the specified range of 75% to 125%. Thus, per USEPA guidelines, all values above the laboratory's estimated detection limit were qualified as estimates, as denoted by the J qualifier.

In summary, based on P4 Production's Cr speciation memorandum and the responses to comments provided herein, evidence supports the elimination of Cr as a contaminant of potential concern in all media but pond, dump seep, and contaminated spring sediments. In addition, we conclude that the use of censored data impairs data quality and raises suspicions of the validity of any consequent evaluations unless performed in a probabilistic manner.

Attachment 1
Statements Against Data Censorship

Many environmental scientists and agencies—including USEPA, USGS, USACE, and USDOE—have realized the undesirable effects of data censorship and documented positions against the practice. Some of their statements are quoted and cited below. Many of these statements are included in a poster presented by MWH not long ago: The poster—M.D. Rettmann, E.A. Dolan, B.A. Narloch, T.M. Nava, P.B. Stenhouse, and W.E. Wright, 2003, *The Case Against Data Censorship*, presented at the 24th Annual Conference of the Society of Environmental Toxicology and Chemistry, Austin, TX—is available upon request.

"Report the actual result of the analysis. Do not report data as 'less than the detection limit.' Even negative results and results with large uncertainties can be used in the statistical test to demonstrate compliance." U.S. Environmental Protection Agency, 1980, *Upgrading Environmental Radiation Data*; Washington, DC, EPA 520/1-80-012, August 1980.

"It is strongly recommended here that, whenever the measurement technique permits, report the actual measurement, whatever it may be, even if it is negative." R.O. Gilbert, 1987, *Statistical Methods For Environmental Pollution Monitoring*, New York, NY, Van Nostrand Reinhold.

"The deletion of censored data or fabrication of values for less-thans leads to undesirable and unnecessary errors." D.R. Helsel, 1990, *Less than obvious: Statistical treatment of data below the detection limit*, **Environmental Science and Technology 24**:1766-1774.

"All of the actual values, including those that are negative, should be included in the statistical analyses." U.S. Department of Energy, 1991, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*; Washington, DC, DOE/EH-0173T, January 1991.

"If the constituent of interest is not present, one would expect negative results to occur as often as positive. In order that valid inferences be made from data sets, it is important that negative results be reported as such." ASTM Subcommittee D19.02, 1994, *Annual Book of ASTM Standards: Standard Practice for Intralaboratory Quality Control*

Procedures and a Discussion on Reporting Low-Level Data. Philadelphia, American Society for Testing And Materials, vol. 11.01, no. D4210-89.

"Results reported as 'less thans; or 'below the criterion of detection,' are virtually useless for either estimating outfall and tributary loadings or concentrations for example." ASTM, 1994, *ibid.*

"Deletion of non-detects is not recommended as it results in excessive loss of information and power as amount of censoring increases." U.S. Army Corps of Engineers Waterways Station, 1995, *Environmental Effects of Dredging Technical Notes*, USACE Environmental Laboratory, EEDP-04-23 July 1995, Vicksburg, MS.

"Because of the large relative uncertainty (percentage error as opposed to absolute error) at low concentrations, many environmental investigations have purposely avoided reporting the very low concentrations at or below the MDL. Even with their high uncertainty, however, these concentrations are the best estimates of the true concentrations that are available and can be useful for many types of data analysis." P.D. Capel, R.J. Gilliom, S.J. Larson, 1996, *Interpretation of Data on Low-Level Concentrations of Pesticides in Water*. Schedule 2001/2010: Guidance on Interpretation, U.S. Geological Survey National Water Quality Assessment.

"The availability of uncensored but qualified low concentration data for interpretation and statistical analysis is a substantial benefit to the user." C.J.O. Childress, W.T. Foreman, B.F. Connor, and T.J. Maloney, 1999, *New Reporting Procedures Based on Long-Term Method Detection Levels and Some Considerations for Interpretations of Water-Quality Data Provided by the U.S. Geological Survey National Water Quality Laboratory*. Reston Virginia: USGS Open-File Report 99-193.

"A detection value below detection limit is still a better estimate of 'truth' than the statement "< detection limit." D.G. Smith, P.B. McCann, 2000, *Water Quality Trend Detection in the Presence of Changes in Analytical Laboratory Protocols* [online], New York City's Department of Environmental Protection's paper presentation at the National Water Quality Monitoring Council Annual Conference in Austin, Texas in April, 2000, http://www.nwqmc.org/2000proceeding/papers/pap_smith%28b%29.pdf [accessed May 30, 2003].

"When the water quality limit is lower than what can be quantified with appropriate analytical methods, the laboratory should be required to submit both detection and quantitation limits and to report "trace" results—results that are able to be detected but not quantified." California Environmental Protection Agency, 2000, *Regional Water Quality Control Board Central Valley Region, A Compilation of Water Quality Goals*, Sacramento, CA.

Attachment 2
Determination of the Proportion of Cr(VI) in Total Cr:
A Comparison of Uncensored and Censored Datasets

Using the data presented in M. Rettmann and B. Wright, MWH (Memorandum to R. Clegg, IDEQ) June 1, 2005, the proportion of Cr(VI) to total Cr is calculated using (1) uncensored data and (2) censored data. For the censored data analysis, one-half the reporting limit, the laboratory's EDL, is used as a surrogate value in the calculations.

The data and results of the two analyses are summarized below in Tables 1 and 2, respectively.

Table 1. Data—Censored and Uncensored.

Medium	Station	Cr, mg/kg dw			
		Censored		Uncensored	
		total Cr	Cr(VI)*	total Cr	Cr(VI)
Pond Sediment	MSP019	450	0.10	450	-8.1
	MSP055	940	0.10	940	-4.1
	MSP059	870	0.10	870	-14
Stream Sediment	MST067	320	0.10	320	-35
	MST089	110	0.10	110	-15
	MST130	100	0.10	100	-9.2
Stream Riparian Soil	MST067	120	0.10	120	-38
	MST089	48	0.10	48	-38
	MST130	95	0.10	95	-9.3
Surficial Waste Rock	MWD080	900	7.3	900	7.3
	MWD086	990	0.10	990	-6.3
	MWD091	1,100	17	1,100	17

*0.10 mg/kg dw substituted for a value < 0.20 mg/kg dw.

Table 2. Results—Means and 95th Percentiles from Censored and Uncensored Data.

Medium	Proportion of Cr(VI)			
	Censored Data		Uncensored Data	
	mean	95th percentile	mean	95th percentile
Pond Sediment	0.00020	0.00048	-0.0079	0.023
Stream Sediment	0.00071	0.0011	-0.12	-0.082
Stream Riparian Soil	0.0020	0.0055	-0.41	-0.067
Surficial Waste Rock	0.0073	0.016	0.0031	0.019

From Table 1 one sees that most of the variability in the Cr(VI) data is lost because of censoring. The statistic has no meaning other than being useful for comparison purposes, but the sample standard deviation of the twelve uncensored Cr(VI) data is 17 mg/kg dw, while that for the censored equivalent is only 5.1 mg/kg dw. This loss of variability does not propagate through to the results because even though the Cr(VI) data are relatively invariable due to censoring, the total Cr data have considerable variability, and thus the proportional ratios of Cr(VI) to total Cr appear to be variable. However, this is a false variability and cannot be relied upon.

Table 2 shows that the means of censored data are always higher than those of the corresponding uncensored data. This is inevitable when all data are below the limit of detection and their surrogate values are set at one-half that limit. For pond sediment and surficial waste rock, censoring produces an underestimation of uncertainty as measured by the range of the data (e.g., see the 95th percentiles). Underestimation of uncertainty leads to overconfidence, which in turn may lead to poor decision making.